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CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

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DEPARTMENT OF NATURAL RESOURCES

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A SELF-FILLING QUAIL WATERING DEVICE

By Ben Glading [1]
Bureau of Game Conservation
California Division of Fish and Game

Water is assumed to be an important factor in the management of the western species of quail. Many different types of artificial watering troughs have been devised and used to provide supplementary water for quail in arid regions (Rahm, 1938; True, 1933). The writer has used many of these devices during the course of investigations into the management of valley quail, but none of the various types of installations tested have proved entirely satisfactory.

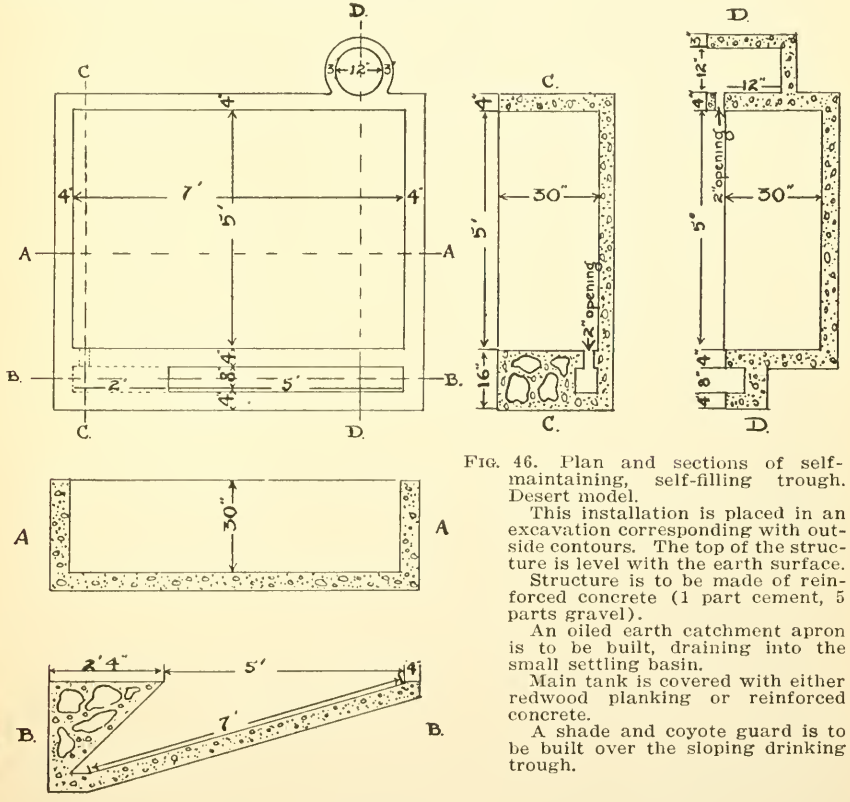

Fig. 46. Plan and sections of self-maintaining, self-filling trough. Desert model.

This installation is placed in an excavation corresponding with outside contours. The top of the structure is level with the earth surface.

Structure is to be made of reinforced concrete (1 part cement, 5 parts gravel).

An oiled earth catchment apron is to be built, draining into the small settling basin.

Main tank is covered with either redwood planking or reinforced concrete.

A shade and coyote guard is to be built over the sloping drinking trough.

The small capacity of most of the quail watering troughs tried has necessitated several filling and inspection trips per season, while mechanical difficulties have been present in nearly all cases, making the use of such tanks a positive hazard to any population of quail entirely dependent on them. In some instances the reservoir would not maintain its supply

[1] Submitted for publication, June, 1943.

of water for more than a few days, while in others, failure of the dispensing device resulted in no water getting to the trough where it could be used by the quail. It is of paramount importance, when such watering installations have been successful in attracting quail to otherwise barren areas, that their operation be sure and be such as to require as few maintenance visits as possible.

The quail watering device described here is felt to be free from practically all types of mechanical difficulties and if properly installed, should require only one visit per year for cleaning. In certain types of terrain, visits could be made even less frequently. The first structure of this new type was placed at the Bitterwater Experimental Area [2] in southern San Benito County, California, in the summer of 1942. In 1943, three more similar installations were made at Bitterwater, one at Kettleman Hills, and two in southern California on quail refuges near Riverside.

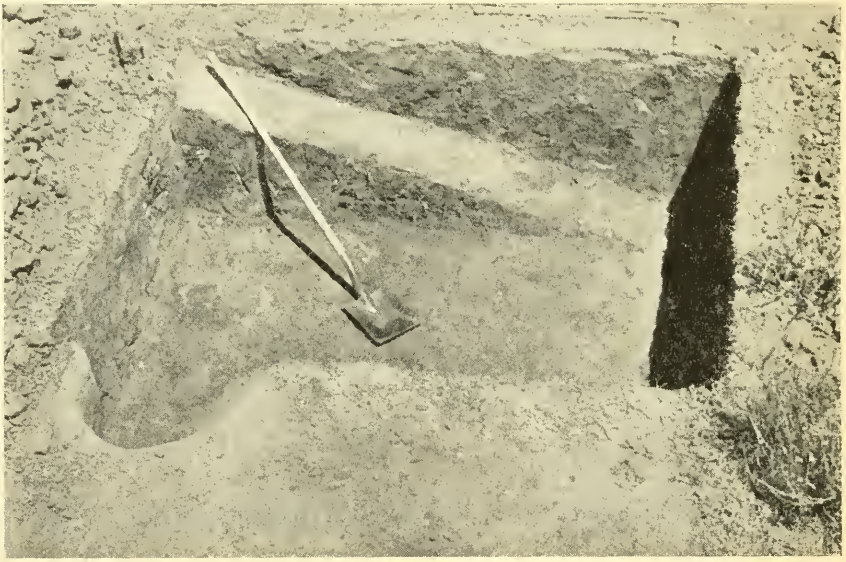

FIG. 47. Excavation for Gavilan installation (southern California quail refuge). Note outside form of settling basin in lower left and of trough at the upper edge of picture.

This tank-trough combination, which has come to be called the "gallinaceous guzzler," is placed so that the top of the tank is flush with the ground surface. The inside dimensions of the first tank employed at Bitterwater were 5 feet by 5 feet by 26 inches deep; its walls and bottoms were of reinforced concrete 4 inches thick. A concrete trough 7 inches wide and about 5 feet long, sloping from ground level to a 26-inch depth, was built parallel to the tank along one entire edge (Fig. 46). The tank and trough had one side wall in common, with a two-inch opening at the bottom to connect the two. (See Figs. 47 to 51 for tank in construction.)

[2] One of the experimental areas of Federal Aid in Wildlife Restoration, Project California 6R, The Management of Valley Quail in the South Coast Counties of California. Grateful acknowledgment is hereby extended to Messrs. David Selleck, Fred Ross and R. W. Enderlin, of Project 6R, for many suggestions pertinent to the construction of these watering devices; and to Fred Ross for drawing Figures 46, 53 and 55.

FIG. 48. Covering inside form of trough with building paper to facilitate removal. Note 2-inch pipe attached to lower side of form; this will form the connection between tank and trough.

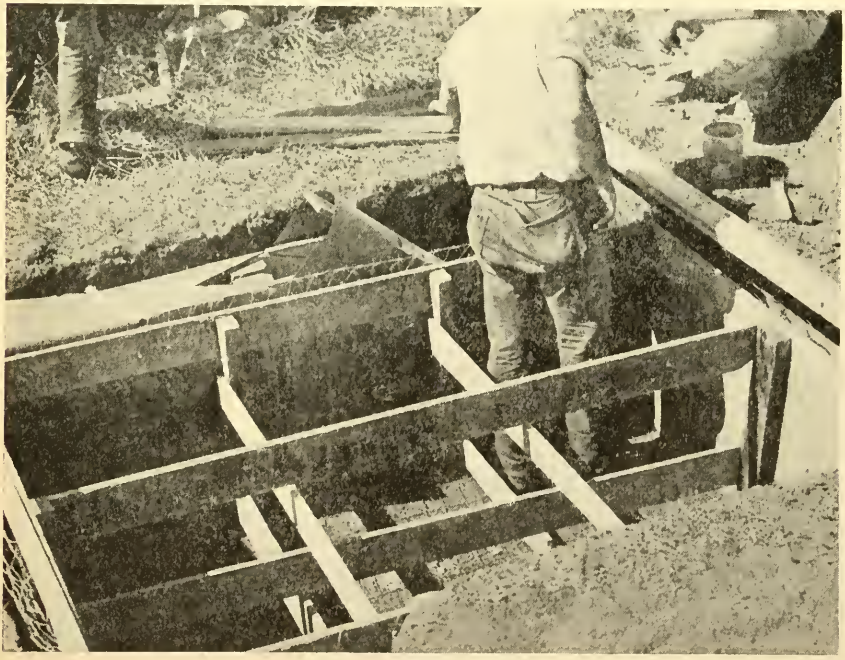

FIG. 49. Tank and trough form in place. Note hog-wire reinforcing between forms and in bottom of tank.

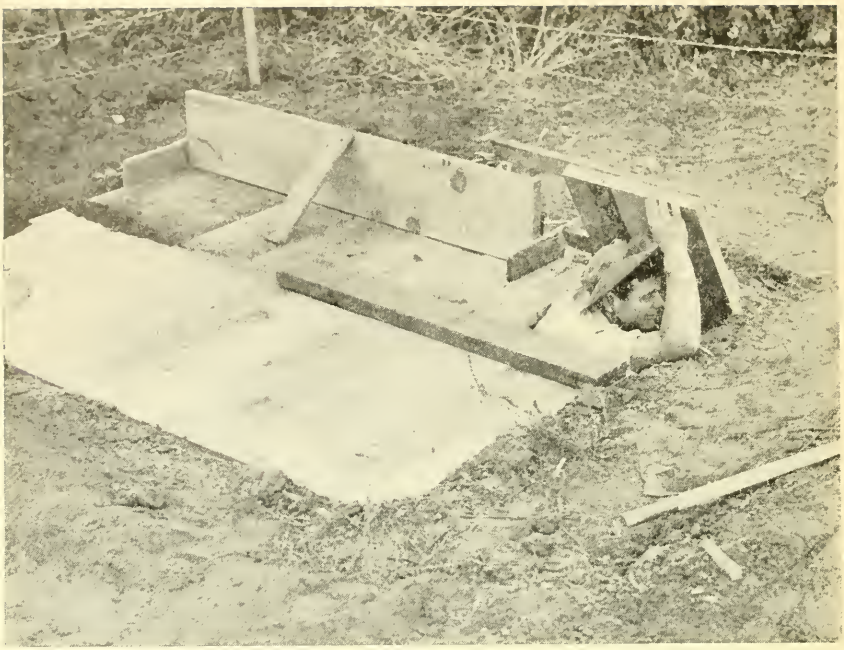

FIG. 50. Gavilan (southern California quail refuge) tank with wooden cover. Manhole for cleaning is at lower right.

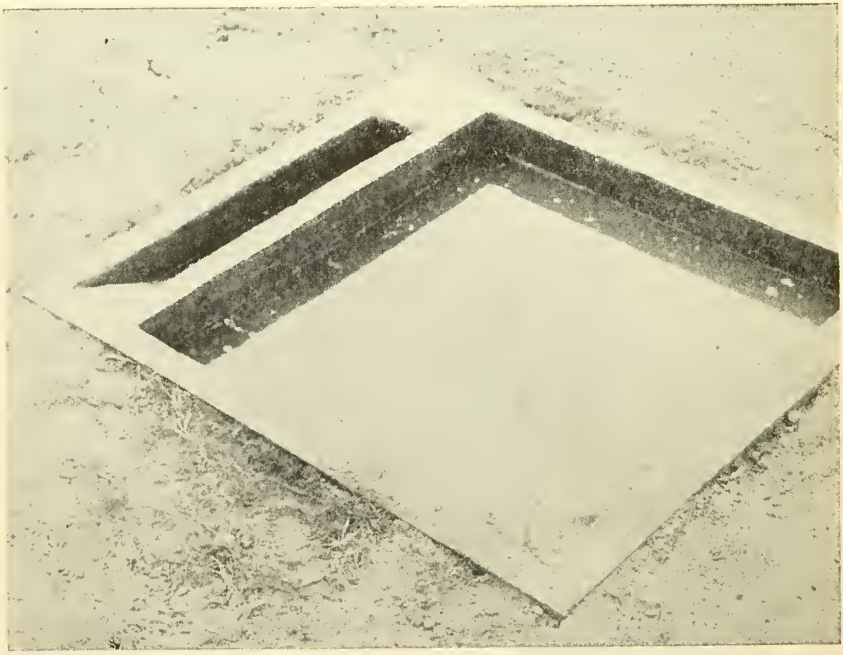

FIG. 51. Bitterwater Tank #6, three-fourths full of water, prior to roofing with redwood planks.

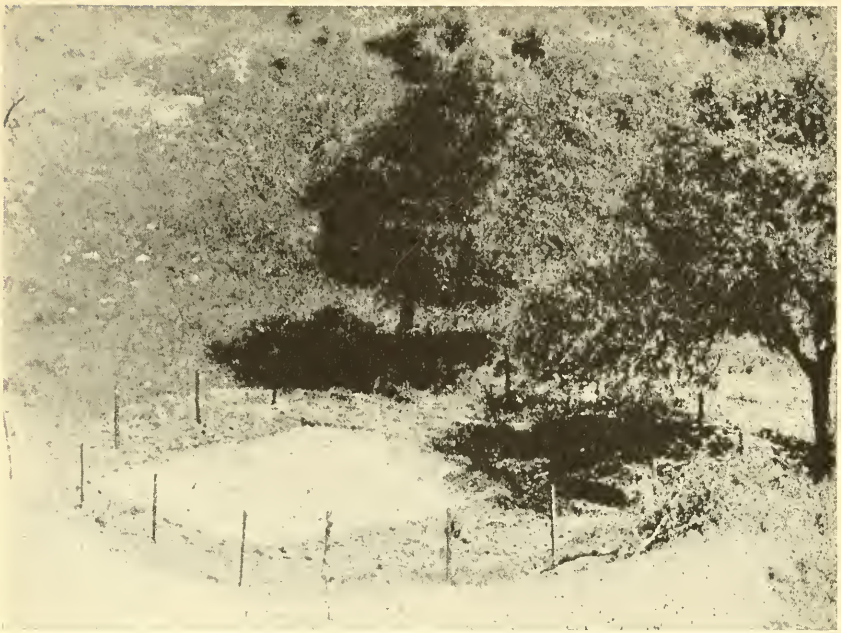

FIG. 52. Completed Bitterwater Tank #6; collecting apron has not yet been oiled, nor has shade been placed over trough.

The tank was then covered with redwood planking and 8 inches of earth. A coyote-proof exclosure and a shade were placed about the trough. (See Figs. 52 and 55 for completed tank.)

Thus, it will be seen that the 400-gallon reservoir is in hydrostatic equilibrium with the drinking trough, and all that is necessary is for the quail to follow the gradually receding water. One complete season's operation has demonstrated that this installation will maintain a supply of water throughout a moderately dry California summer. A somewhat larger tank may be necessary for more arid regions.

The tanks installed in 1943 were of more than 600-gallon capacity, in anticipation of developing such a tank for desert use. The inside dimensions of the storage tanks on the larger square installations were 7 feet by 5 feet by 30 inches, and the trough was correspondingly enlarged. (See Fig. 46 for details of these larger types.) Two of the 1943 structures placed at Bitterwater were made with a circular tank 7 feet in diameter and 30 inches deep (Fig. 53). The form for pouring this type of concrete trough is somewhat more difficult to make and is recommended only for situations where a number of installations are contemplated. It has the advantage however that once the original form has been built, the resulting installations are easier to pour and more strongly constructed.

The 1943 installations were supplied with a solid concrete cover for the storage tank, and a manhole and cover 18 inches in diameter to allow access to the tank for cleaning (Fig. 54).

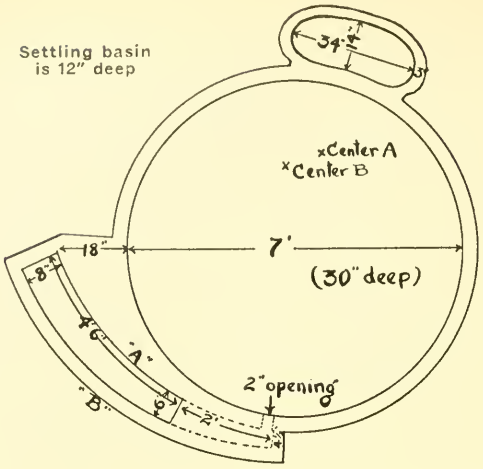

FIG. 53. Circular modification of quail watering device. Original forms for this type are more difficult to build than for the square model, but this type is better for mass production. Construction details similar to square model. Radius of curves for sides of trough is 6' from center "A" (inside wall) and center "B" (outside wall). Trough slopes from ground level at 8" end to 30" deep at 4½" end.

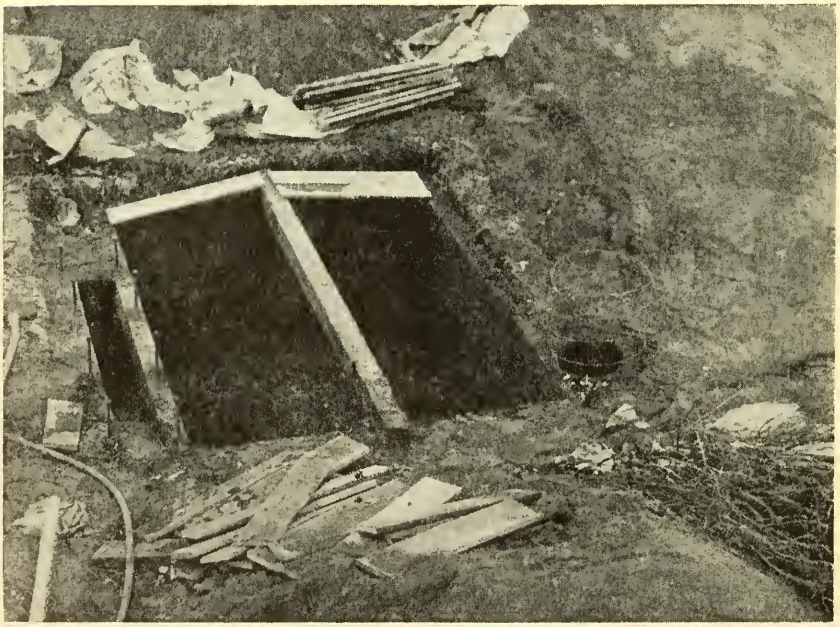

FIG. 54. Box Springs (southern California quail refuge) installation just after removal of forms. Bolts have been set in the concrete surrounding the trough to hold coyote guard and shade. The form for the concrete roof is being installed. The manhole will be in upper left corner of the tank, and a wash-tub will serve as inside and outside form for hole and cover. Settling basin with screen at lower right corner.

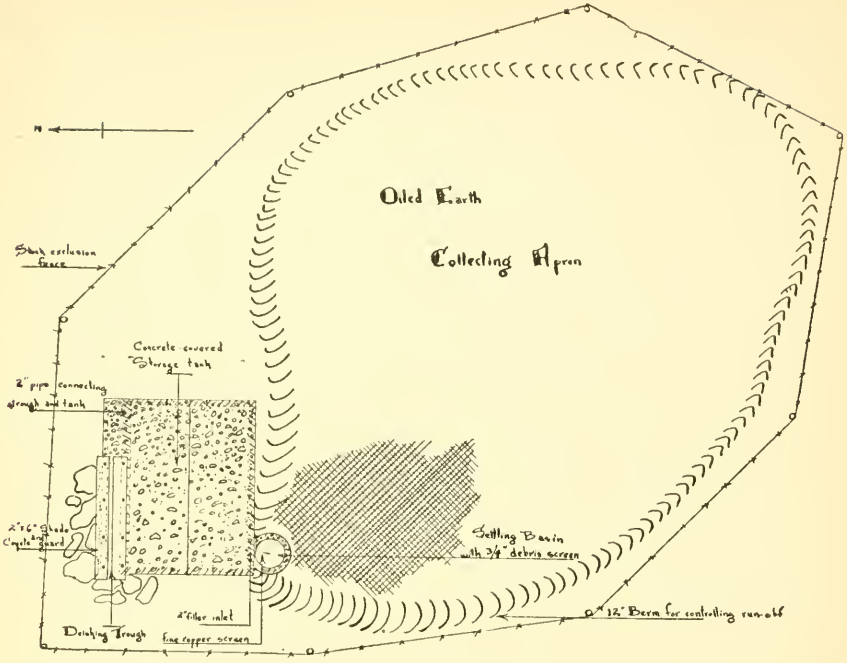

FIG. 55. General ground plan for complete installation, showing position of rain collecting apron, shade and coyote guard, and fence.

In order to do away with the necessity for annual filling of the tank, a rain-collecting apron was built uphill from it and connected to it by a settling basin that led into the tank by a two-inch opening (Figs. 52 and 55). The area of this apron was calculated so that one-half of the minimum possible annual rainfall of the locality (about 3 inches in the case of the Bitterwater structures) would fill the reservoir. The collecting apron on Bitterwater tank #6 was roughly circular and about 18 feet in diameter. A screen was placed about the settling basin, in order that floating debris would not accumulate in it. A fine screen was placed in the opening between the settling basin and the tank. The collecting apron was constructed by first cleaning off all vegetation, then shaping it up with a six-inch berm at the periphery. During the heat of the summer, hot road oil was spread over the apron and allowed to soak in. A second application of road oil may be necessary during the second summer of operation.

Following is a list of materials needed for the "desert" or larger square model: lumber for forms, roughly 100 board feet of #3 pine 1" x 6", and nails; building paper for wrapping trough form; 12 sacks of cement for tank-trough-settling basin structure; and 2½ yards of mixed sand and gravel. If a concrete top is to be made this will require about 2½ sacks of cement and about ½ yard of gravel additional; if a redwood plank top is to be made, this will require about 80 board feet of redwood 2" x 12" and several lengths of 2" x 4" redwood. Screen will be needed for the settling basin and inlet to the tank; ½" hardware cloth is good for the debris screen surrounding the settling basin, while copper fly screen

should be used in the opening from the settling basin to the tank. The shade and coyote-proof guard over the trough can be made with bolts set in the concrete, supporting two two-by-six planks laid flat (Figs. 54 and 55), or may be constructed of logs. About 25 gallons of road oil is required for treating the catchment apron. The whole construction, including excavation, setting up forms, pouring concrete, preparing and oiling the catchment basin and fencing the whole installation can be done by experienced workers in five man-days. This does not include labor for hauling materials, which would vary with the locality of installation.

This type of tank has worked perfectly as far as hydrostatic operation is concerned during the year and a half the first one has been in service. No quail were attracted to it the first summer due to its excessive use by bees. This was cured, however (Glading and Selleck, 1943), and quail use was observed during the summer of 1943.

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A BEE REPELLENT FOR USE IN QUAIL WATERING DEVICES

By Ben Glading and David M. Selleck [1]
Bureau of Game Conservation
California Division of Fish and Game

A common difficulty encountered in the operation of artificial water troughs for arid land game is their invasion by bees. Various workers have reported that bees have taken over their installations, quickly draining the tanks and driving game away. Bees can take an unbelievable quantity of water. Gordon H. True, Jr. states that a 50-gallon barrel in southern California was drained by bees in 10 days. Our observation at Tank #6, Bitterwater, California (Glading, 1943) revealed that bees took approximately four gallons per day over a 17-day period.

A solution to this difficulty presented itself somewhat accidentally during the course of a quail watering experiment conducted at Bitterwater in southern San Benito County, California.[2] It was noted that five out of six quail troughs installed in this area were infested in varying degrees by bees from a nearby apiary, and by wild bees. The remaining trough (Bitterwater #4) was a 400-gallon float valve installation which had a reservoir consisting of a discarded acetylene generator. This tank was lined with a thick coating of carbide residue (Ca $[OH]_2$ plus impurities).

In order to test the possibilities suggested by the lack of bees at this old carbide tank, the following experiments were devised.

Tank #6, which had the worst infestation, was used as the site of the tests. Water similar in source to that in Tank #6 was placed in a five-gallon can near the trough for several days. During this period, as stated above, the bees drank approximately 70 gallons in 17 days from the quail watering device. The trough was then screened so that bees had to rely on water from the nearby five-gallon can. Four cans (approximately three-quart capacity) were then placed nearby and treated as follows:

#1—filled with water from same source as Tank #6.

#2—filled with water from same source as Tank #6 and enough carbide residue to make a saturated solution.

#3—filled with water from same source as Tank #6 and enough commercial hydrated lime (Ca $[OH]_2$) to make a saturated solution.

#4—filled with water from same source as Tank #6 and screened from bees.

A sloping screen $1\frac{1}{2}''$ wide was placed in each can, with the exception of Can #4, to allow easy access by the bees.

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[1] Submitted for publication, June, 1943.
[2] Federal Aid in Wildlife Restoration, Project California 6R, The Management of Valley Quail in the South Coast Counties of California.

The five-gallon can from which the bees had been drinking was removed, and the bees were forced to choose from the test cans. Table 1 shows the results of this experiment after 24 hours exposure to bee use.

TABLE 1

Can No.	*Treatment*	*Loss of H_2O in 24 hours*
1	H_2O	5⅝ ozs.
2	Saturated carbide residue	10⅜ ozs.
3	Hydrated lime	10⅜ ozs.
4	H_2O screened	10⅜ ozs.

It was noted that bees swarmed about the plain water but left both the carbide and hydrated lime treated waters alone. This seemed to be conclusive evidence that bees were repelled by the lime water.

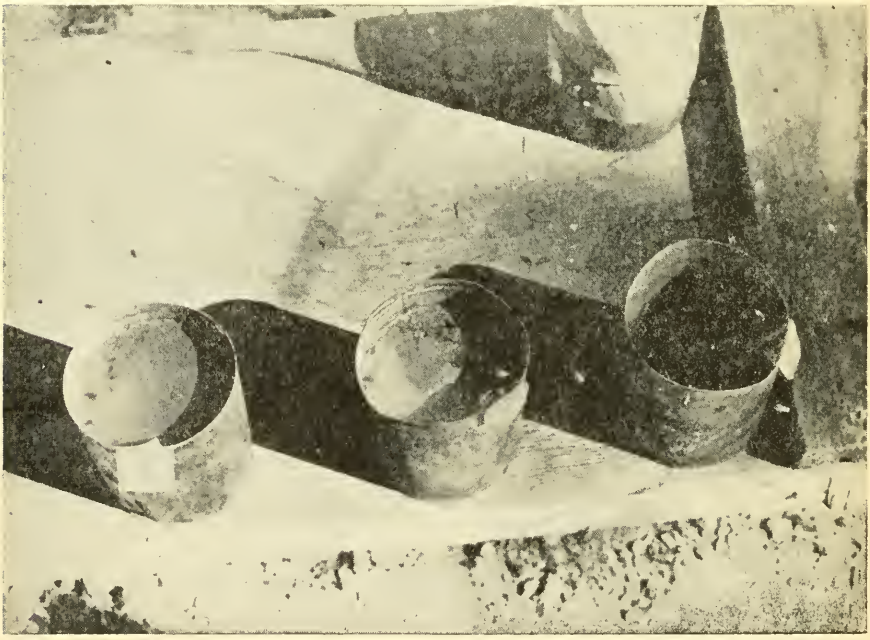

FIG. 56. Bee-repellent experiment after one day's exposure to bee use. The lefthand and center cans contain a saturated solution of carbide residue and slaked lime, respectively, while the righthand can has just a few inches of plain water remaining in it. The can on the upper right was screened against bees as a check; its water loss was approximately the same as that in the two treated cans.

The next question was, would quail continue to use troughs filled with a saturated calcium hydroxide solution. Accordingly, Tank #5, a vacuum installation that had considerable quail use, was treated with enough hydrated lime to produce a saturated solution. About five pounds of lime to 100 gallons of water was enough to saturate the drinking water. Quail use at this installation continued after the treatment. The other Bitterwater troughs, all of which had some quail use, were similarly treated with enough water-slaked lime to make a saturated solution, and bee use was immediately greatly reduced, while quail use continued.

In the summer of 1943, a number of bees were again seen about Tank trough #6. It was observed, however, that they were not taking water from the drinking trough itself, but were gaining access to the main tank chamber through a hole in the roof and were drinking water that was condensed in drops on the roof. The hole in the roof of the tank was plugged. The bees then availed themselves of water that crept up the sides of the trough by capillary action. It was noted that the bees were drinking this capillary water about one inch above the surface of the water in the trough. Between the water surface and the line of bee drinking, there was a precipitate of what was presumed to be $Ca\ Co_3$ (it bubbled when put in vinegar). Carbon dioxide of the air acting on the $Ca\ (OH)_2$ of the lime water exposed by capillary attraction removed the calcium hydroxide from the water and left a precipitate of calcium corbonate about one-half inch above the water surface; the water above this line was devoid of lime, hence acceptable to bees. Water loss from this type of use by bees was negligible compared with the use of untreated water. It is suggested that where concrete troughs are used that they be coated with any of the wax concrete coating compounds; this will reduce capillary action on the sides of the troughs.

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Glading, Ben
1943. A self-filling quail watering device. California Fish and Game, vol. 29, no. 4, pp. 157-164.

EPIDEMIOLOGICAL STUDIES ON COCCIDIOSIS OF CALIFORNIA QUAIL

I. OCCURRENCE OF *EIMERIA* IN WILD QUAIL[1]

By CARLTON M. HERMAN and JOHN E. CHATTIN
Bureau of Game Conservation
California Division of Fish and Game

Introduction

Coccidia, protozoa which usually parasitize the epithelium lining the intestines and caeca, occur in a great variety of animals. Although a number of genera have been described, only two (*Eimeria* and *Isospora*) are common in birds and mammals. For the most part species of coccidia which occur in one species or group of birds or mammals are not infective to other species or groups. Thus the coccidia of cattle are infective only to cattle, the coccidia of sparrows will not infect chickens or quail, and most of the species observed in quail and chickens are not transferrable between these two hosts. All of the species of coccidia which have been reported from quail or which we have observed from these birds belong to the genus *Eimeria*. Three species thus far have been named and described from quail in California, but we have observed at least five species.

The life cycle of coccidia is, in general, very similar for all species. These parasites are ingested by mouth and usually infect the cells lining the intestinal tract. Resistant oöcyst stages pass out of the intestinal tract with fecal droppings and in the case of the quail forms studies, reach infectivity (complete sporulation) within 48 hours, at which time they are capable of causing infection in susceptible animals which eat them.

A number of reports have been made of the presence of coccidia in quail in California and other areas of the United States, and in related game birds in various parts of the world. However, the present paper presents the first extensive survey of the occurrence of these parasites in a species of wild bird.

O'Roke (1928) examined an unstated number of wild quail from several areas in California and observed no coccidia. He later (in McLean, 1930) noted the occurrence of four species of *Eimeria* in valley quail raised in an aviary. Two species of *Eimeria*, with a questioned third, were identified by Henry (1931) from California quail (*Lophortyx californica*) and mountain quail (*Oreortyx picta*) from game farms, together with a few wild birds. Herman and Jankiewicz (1942) recognized three species of *Eimeria* in both wild and captive quail. Four species of *Eimeria*, with a possible fifth, were recognized by Herman, Jankiewicz and Saarni (1942) from trapped quail at the San Joaquin Experimental Range. These last authors examined 121 birds during the period between April and October, 1941, and reported infection in 89. The percentage of infection was higher in adult than in young birds. A

[1] Submitted for publication, June, 1943.

rise and fall in intensity of infection was observed in individual birds at different samplings. Monthly incidence decreased from April (94.7%) to September (23.8%) and showed an increase in October, suggesting a possibility of seasonal variation. Herman, Chattin and Saarni (1943), in a further analysis of this same material from the Experimental Range plus samples collected subsequently, found a variation in the monthly intensity of infection which seemed correlated with the food habits of the birds.

Acknowledgments

The material reported in this paper was studied at the Los Angeles Wildlife Disease Research Station of the U. S. Fish and Wildlife Service during which time the senior author was Technical Advisor. Work Projects Administration Official Project No. 65-2-07-344 performed the routine procedures incident to the preparation of the material for microscopic examination.

This is part of an extensive cooperative project on the causes of wildlife fluctuations and animal diseases. The fecal samples were collected in part by the personnel of the California Division of Fish and Game, forming the staff of Federal Aid in Wildlife Restoration Project, California 6R (The Management of Valley Quail in the South Coast Counties of California), and in part by other field personnel of the Division. The soil samples were collected by Ben Glading, David M. Selleck, and Elmer C. Aldrich of the Division, working on the Federal Aid project, and by Roy Saarni of the U. S. Forest Service. The samples collected by the latter cooperator were part of a cooperative study with the Forest Service, the U. S. Fish and Wildlife Service, and the University of California. Although extensive, detailed field notes were kept by these workers concerning the collection of the soil samples, only a brief statement summarizing the technique of collection and source of this material is included in the present paper.

Materials and Methods

Quail (*Lophortyx californica* subsp.) were trapped in 19 areas in California, numbering from 4 to 239 birds during trapping periods which varied from 1 day to 1½ months; most collections covered a period of less than 1 week. Three separate samplings were taken from birds at Bitterwater, San Benito County, and 7 samplings were made at the Dune Lakes Club, San Luis Obispo County. At the latter area, portions of intestinal tracts were collected from birds shot by hunters during the period from November 15 to December 31, 1941.

The locations from which samples were obtained are shown in the accompanying map (Fig. 57). Because of the artificial nature of the quail management at the Dune Lakes Club and the large series of samples studied from that area, a brief description of the locality is presented. It is located on the coast in San Luis Obispo County. The area is composed mainly of low, rolling sand hills, made up of fine sand with practically no humus. It is extremely well drained. Rainfall occurs only in winter months and during 1941 registered about 30 to 40 inches. A heavy morning dew and several lakes provide an abundant summer water supply for the birds. Cover, consisting of sandhill brush species, is very

ample. Annual legumes and filaree are practically absent. Usually preferred quail foods are almost lacking during the summer but green food is available from the first rain until late April. However, the birds are fed artificially at least twice a week and crop studies show cracked corn forms the bulk of the diet throughout the year. Census counts by Glading and other field cooperators indicate that during the period of sampling there were about 2,000 quail inhabiting a 400-acre area.

The birds trapped at Modjeska, Orange County, were removed shortly thereafter to Dune Lakes where they were kept confined in pens for more than a month before samples were taken and hence may be considered as captive birds. Samples from several game farms are included for comparative purposes.

The trapped quail were placed in individual cages and confined until droppings were deposited. Figure 58 illustrates the type of cage developed on the Federal Aid project for this purpose. The sample was

FIG. 57. Map of California showing sites from which fecal samples from quail, and soil samples, were collected for this study.

placed, while still moist, in a vial containing sufficient 2 per cent potassium dichromate solution to cover the fecal material. This chemical inhibits bacterial development and serves to preserve the coccidial oöcysts in good condition for subsequent diagnosis in the laboratory. Each vial received droppings from only one quail and was labeled with the band number of the bird and the date on which the sample was collected.

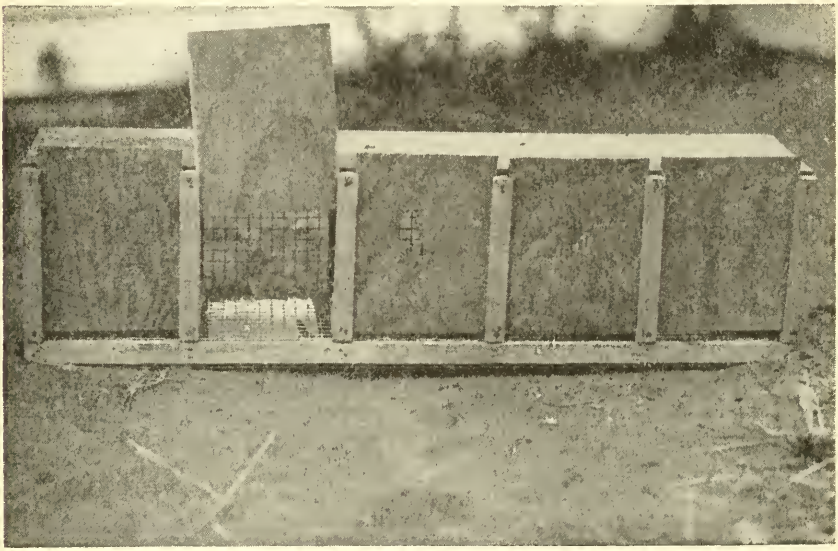

FIG. 58. Holding cage used for securing fecal samples from quail. Clean sheets of paper were placed under each compartment to catch the droppings. Photographed by Ben Glading.

In the laboratory the entire sample was placed in a 15 ml. centrifuge tube which was filled with water and spun at about 2,000 revolutions per minute for 90 seconds. The coccidial oöcysts, having a greater specific gravity, were thrown to the bottom of the tube. The supernatent fluid was then decanted and the centrifuge tube was filled with zinc sulfate solution made up of 331 grams per liter of water (specific gravity 1.180 as per Faust et al., 1939) and recentrifuged at about the same rate of speed for an additional 60 seconds. This change of specific gravity causes the coccidial oöcysts to float on the surface of the liquid. A drop of the surface film was removed from the tube by adherence to the flattened end of a glass rod and transferred to a microscope slide. The entire drop was examined under the low power of a compound microscope (5× ocular and 10× objective—yielding a magnification of 50×) and the findings were rated according to the number of coccidial oöcysts present as follows: 1-10 oöcysts, 1+; 11-50, 2+; 51-100, 3+; 101-500, 4+; 501-1,000, 5+; 1,001-5,000, 6+; over 5,000, 7+.

Soil samples were collected as follows:

1. San Joaquin Experimental Range, in the foothills of the Sierra Nevada near O'Neals, Madera County. The incidence and intensity of coccidian infection of quail on this area has been reported in a previous paper (Herman, Jankiewicz and Saarni, 1942). Soil samples, usually sufficient to fill a 2-ounce jar, were collected from a variety of locations.

In all cases samples were taken only from areas frequented by concentrations of quail. These were primarily at water holes. Samples were taken at various depths from the surface to a depth of 1 inch, and included wet material close to water holes, soil at various distances from the holes, at the fringes of wet and dry areas, and also dry soil several feet from the water holes where quail were likely to dust themselves. When a water hole became dry and therefore no longer used by the quail, no further samples were taken. A total of 556 samples was collected during the period between May, 1941, and January, 1942.

2. Dune Lakes Club. Soil samples, usually sufficient to fill a 1-pint carton, were collected as at the San Joaquin Experimental Range from a variety of locations frequented by concentrations of quail. One hundred seven samples were collected on July 2, 1941, and 103 further samples were collected on December 11, 1941; the latter samples were mainly from approximately the same spots as the first sampling. In most cases four samples were taken from each spot at odd ½-inch depths; i.e., the first ½ inch, the third ½ inch, etc.

3. Quien Sabe Ranch. All soil samples from this area were collected from about a single spring on May 6, 1941. The shallow spring was situated at the base of a cliff, the terrain sloping away from the cliff in a gradual decline across a meadow. The ground immediately around the spring contained many loose stones and boulders and was well shaded. From about 8 feet away from the spring the meadow was unshaded and served as cattle pasture. The nature of the terrain immediately around the spring makes it unlikely that the cattle used it for watering purposes, but there was positive evidence that it was used by predatory mammals as well as quail and other birds. Samples of soil were collected from the spring and the moist soil surrounding it and at intervals in two directions away from the spring across the pasture for about 300 yards. A total of 103 samples of soil was collected in 1-pint cardboard containers. They were collected at varying depths, but mostly on the surface ½ inch. Close to the spring, samples were taken at distances of a few inches apart, and the interval was increased in the two directions away from the spring. Several of the spots close to the spring under the shadows of boulders appeared to be used by the quail as dusting or resting places.

The soil samples varied from 2 ounces to 1 pint of material. Each individual sample was thoroughly stirred to insure a homogeneous mixture and, roughly, 2 grams were weighed out. The 2-gram samples were then treated in the same manner as the fecal samples, as described above. In the first five samples of material received from the Experimental Range, six 2-gram tests of each sample were compared and it was decided that the results were sufficiently comparable to consider a single 2-gram sample an adequate examination.

Results

All coccidia observed from quail feces or intestinal material belonged to the genus *Eimeria*. No attempt was made in this study to differentiate species of the parasite.

The findings obtained from the examination of 3,500 fecal samples of quail, and the contents of portions of intestinal tracts from the Dune Lakes hunt, are presented in Table 1. In the areas where fecal samples

TABLE 1

Incidence and Relative Intensity of Coccidian Infection in Quail

Locality	County	Trapping dates	Total examined	Per cent positive	Per cent 1+	Per cent 2+	Per cent 3+	Per cent 4+	Per cent 5+	Per cent 6+	Per cent 7+
Arcata	Humboldt	Oct. 13-Nov. 3, 1941	152	92.8	38.2	21.1	18.4	14.5	-----	.7	-----
Fort Bragg	Mendocino	Nov. 11-13, 1941	19	84.2	52.6	15.8	10.5	5.3	-----	-----	-----
Inverness	Marin	Sept. 24-Oct. 10, 1941	143	58.1	25.2	12.6	9.1	9.1	2.1	-----	-----
Surprise Valley	Modoc	Feb. 1-26, 1942	34	47.1	32.4	5.9	2.9	5.9	-----	-----	-----
Litchfield	Lassen	Nov. 7-Dec. 10, 1941	92	19.6	14.1	4.4	-----	1.1	-----	-----	-----
Corning	Tehama	Nov. 23-Dec. 16, 1941	187	96.8	19.2	21.9	20.3	26.7	6.4	1.6	.5
Hillsborough	San Mateo	Aug. 22-Oct. 9, 1941	*299	49.7	19.0	7.0	4.3	1.7	.7	.3	-----
Wilder Ranch	Santa Cruz	Oct. 20-Nov. 7, 1941	142	54.6	25.0	14.5	9.2	4.6	.7	-----	.7
Pacific Grove	Monterey	Aug. 8-Nov. 27, 1941	8	87.5	37.5	-----	25.0	12.5	-----	-----	-----
10 Mi. S. Big Sur	Monterey	Aug. 23, 1941	5	40.0	40.0	-----	-----	-----	-----	-----	-----
Jolon-Lockwood	Monterey	Oct. 10-19, 1941	99	61.6	32.3	12.1	10.1	4.0	3.0	-----	-----
Bitterwater	San Benito	July 12, 1941	26	11.5	7.7	-----	3.8	-----	-----	-----	-----
Bitterwater	San Benito	Oct. 10-19, 1941	74	70.3	31.1	14.9	18.9	5.4	-----	-----	-----
Bitterwater	San Benito	Feb. 1-12, 1942	49	77.5	49.0	18.4	6.1	4.1	-----	-----	-----
Quien Sabe	San Benito	Nov. 19-Dec. 10, 1941	60	80.0	30.0	18.3	13.3	16.7	1.7	-----	-----
Suey Ranch	San Luis Obispo	July 26, 1941	4	50.0	25.0	-----	-----	25.0	-----	-----	-----
Shandon	San Luis Obispo	Sept. 12-16, 1941	119	34.4	22.7	5.9	4.2	1.7	-----	-----	-----
La Panza	San Luis Obispo	Nov. 5-8, 1941	115	56.5	25.2	15.6	11.3	1.7	1.7	.9	-----
Dune Lakes	San Luis Obispo	Aug. 30-Sept. 6, 1941	192	67.7	25.5	18.2	9.9	8.9	3.1	.5	1.6
Dune Lakes	San Luis Obispo	Sept. 22-25, 1941	112	78.6	27.7	24.1	17.8	7.1	.9	.9	-----
Dune Lakes	San Luis Obispo	Oct. 24-26, 1941	139	68.3	32.4	18.7	13.0	4.3	-----	-----	-----
Dune Lakes	San Luis Obispo	Nov. 11-14, 1941	129	72.1	29.5	23.3	12.4	7.0	-----	-----	-----
Dune Lakes	San Luis Obispo	Nov. 15-Dec. 31, 1941	**132	70.5	43.2	17.4	5.3	4.5	-----	-----	-----
Dune Lakes	San Luis Obispo	Jan. 13-16, 1942	192	94.3	32.3	24.5	17.2	15.6	3.1	1.0	.5
Dune Lakes	San Luis Obispo	Feb. 13-15, 1942	171	81.2	49.7	16.4	10.0	4.1	.6	.6	-----
Dune Lakes	San Luis Obispo	Mar. 25-28, 1942	103	49.5	32.0	6.8	6.8	1.9	1.0	1.0	-----
Gilroy	Santa Clara	Dec. 2-11, 1941	18	50.0	33.3	11.1	-----	-----	5.6	-----	-----
Modjeska	Orange***	Sept. 19, 1941	174	70.2	51.2	13.2	4.6	.6	.6	-----	-----
Howell (G.B.B.)	San Mateo	Aug. 25-Sept. 11, 1941	35	54.3	37.2	14.3	2.9	-----	-----	-----	-----
Klose (G.B.B.)	San Mateo	Sept. 18-23, 1941	35	42.9	31.5	11.4	-----	-----	-----	-----	-----
Castaic (G.B.B.)	Los Angeles	Feb. 10, 1942	142	46.5	35.9	7.0	2.8	.7	-----	-----	-----

* These 299 samples were taken from 185 birds.
** Examination of fecal material collected from intestines of birds shot during annual hunt.
*** These birds had been kept in captivity for more than a month prior to collection of samples.
(G.B.B.) Captive birds bred in Game Farms.

from 49 or more birds were examined during one period, total infection varied from 19.6 per cent at Litchfield during November and early December, to 96.8 at Corning during approximately the same period.

Intensity of infection varied considerably for different areas and even in the same area at different trappings. In all but one area the greatest number of infected birds had 1+ or 2+, i.e., "light" infections; the samples from birds at Corning had a greater number with 3+ and 4+, i.e., "medium" to "heavy" infections with a greater percentage of "very heavy" infections than birds from any other area sampled. A comparison of the percentage intensity of infections in birds from a few of the areas is shown in the graphs in Figure 59. The points of the solid curves of these graphs are plotted on the intensity of infection as shown in Table 1, i.e., 1+, 2+, etc. The points of the broken curves are the sums of 1+ and 2+, 3+ and 4+, etc., and may be interpreted as "light," "medium to heavy" and "very heavy" infections. All game farm flocks of birds studied, an example of which is illustrated in Figure 59-C, showed a sharp drop from "light" infections to "medium." The same type of curve was obtained from a tabulation of the findings of the birds trapped at Modjeska (Figure 59-A) but kept in captivity for a period prior to collection of samples. The tabulation for the samples from Bitterwater birds trapped in early February, 1942 (Figure 59-B), presents the same type of curve. The March samples from Dune

Lakes, not shown in Figure 59, also give a similar picture. Other tabulations, due to higher percentages of 2+, 3+, or 4+ infections cause the upper curve to have a more gradual drop. Samplings with such findings are shown in the graphs of the Bitterwater, October, samples (Figure 59-D) with a high per cent of 3+ infections, and the Quien Sabe samples (Figure 59-E) with a high per cent of 4+ infections. Only in the

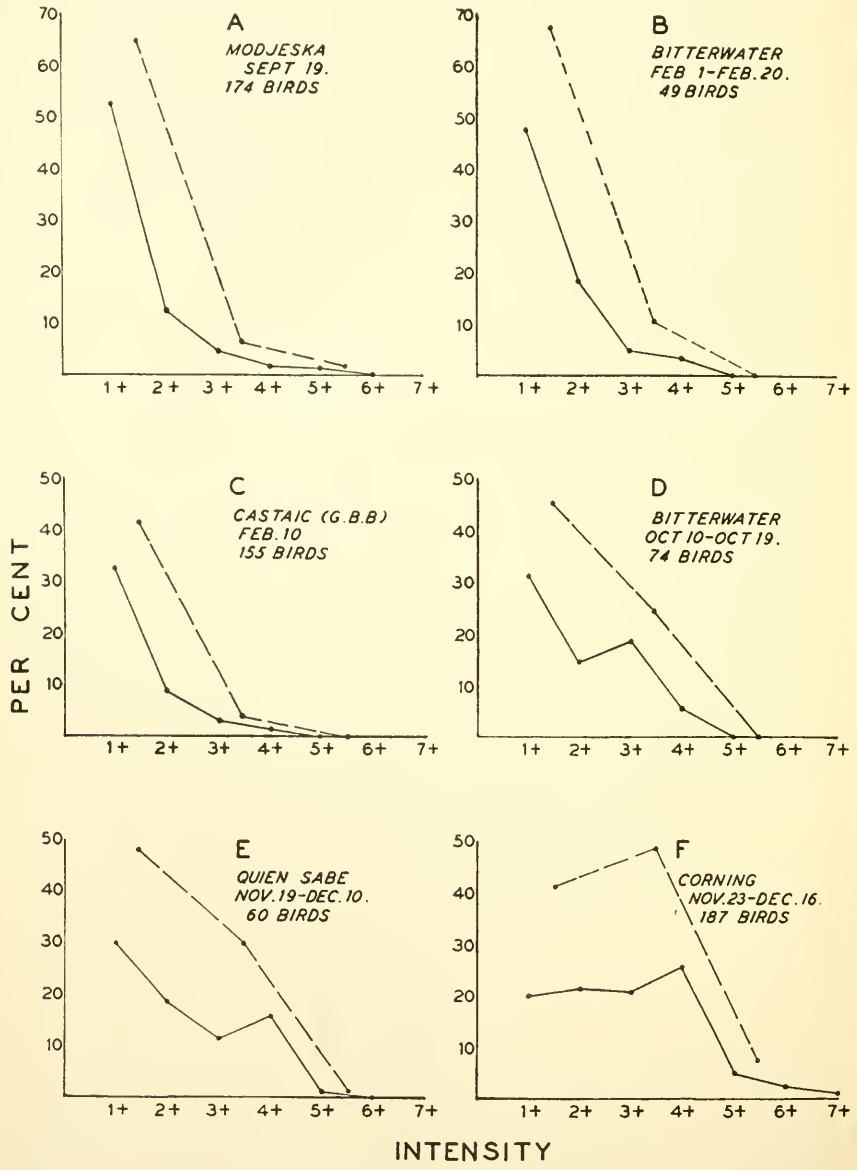

FIG. 59. Solid lines are plotted from observations in Table 1. Broken lines represent the same observations grouped in larger categories; points represent the sums of the intensities of 1+ and 2+, 3+ and 4+, and 5+ and 6+ and may be interpreted as "light," "medium to heavy" and "heavy" infections.

Corning samples (Figure 59-F) was there such a high per cent of 3+ and 4+ infections as to cause the broken curve to show a greater percentage of "medium" to "heavy" infections and thus a rise instead of the fall in the curve that was indicated with the samples from all other areas studied.

From the data obtained from the samplings at Bitterwater and Dune Lakes it is evident that there is a variation in the intensity of infections within a single area at different periods as well as difference between areas. In a previous paper Herman, Chattin and Saarni (1943) showed this to be the case at the San Joaquin Experimental Range. In that paper a curve of the variation in the intensity of infection by months during a period of 11 months was presented and an attempt was made to correlate the curve with the food habits of the birds, suggesting that changes in diet might be a factor. Figure 60, derived in the same manner,[2] yields a similar curve for the intensity of infections of the Dune Lakes birds, with a high point in January just as

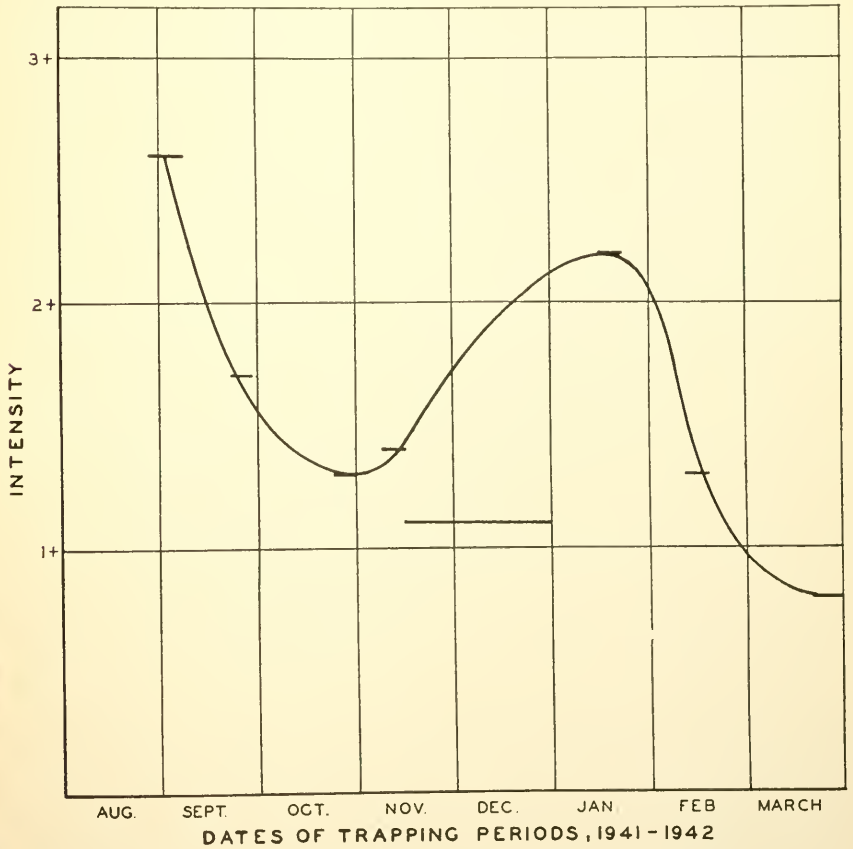

FIG. 60. Varying intensity of coccidian infection at Dune Lakes.

[2] The points in this graph were derived by tabulating all 1+ infections as 1, 2+ as 2, etc., and dividing the sum by the total number of samples examined during the respective period.

it was at the Range. The low point for the samples in November and December may be explained on the basis that this represents material primarily from the main intestinal tracts of shot birds and does not include any caecal infections which may have been present.

TABLE 2

Analysis of Some Repeat Samples of Birds During the February Trapping at Dune Lakes

1st Sample		2nd Sample					3rd Sample			
Findings	No.	Neg.	1+	2+	3+	4+	Neg.	1+	2+	3+
Neg.	4	2	1	1	--	--	--	1	--	--
1+	19	5	14	--	--	--	--	--	--	--
2+	5	1	1	2	--	1	--	--	1	--
3+	2	1	1	--	--	--	--	--	--	--

During the February work at Dune Lakes several of the birds were re-trapped within the three-day period. The findings of these samples are tabulated in Table 2. Of four birds which registered negative in the first test, two were negative, one was 1+ and one was 2+ the second time trapped, and the single bird trapped a third time was 1+. Changes were also evident during the three-day period in birds which were originally positive, some of these showing negative in the repeat samples.

Examination of the soils from San Joaquin Experimental Range revealed coccidial oöcysts in 106 of the 556 samples studied. Of these, 42 had the typical morphology of a common cattle parasite (*Eimeria zurni*); five contained oöcysts of *Isospora* sp., similar to the forms reported from passeriform birds from the same Experimental Range (Herman, Jankiewicz and Saarni, 1942); and 11 had oöcysts similar to those reported from cottontail rabbits on the San Joaquin Range (Herman and Jankiewicz, in press). Of the remaining 62 positive samples, 47 had not sporulated and 15 were *Eimeria* sp. In view of the fact that all studies to date demonstrated that the *Eimeria* of quail sporulated within 48 hours and all samples were not examined until at least a week after collection, it seems logical to conclude that these nonsporulated oöcysts do not represent quail coccidia. In all the 15 samples in which *Eimeria* occurred which might possibly have come from quail, five or less oöcysts were encountered in each 2 gram sample studied. In view of the small numbers of oöcysts encountered no tests were made to determine whether quail would be susceptible to these *Eimeria* and they, just as feasibly, could have come from other animals on the Experimental Range as well as quail.

Of the 107 soil samples examined from Quien Sabe Ranch, 20 revealed coccidial oöcysts. Most of these were represented by a single, nonsporulated, degenerated oöcyst, two from the pasture area were of the E. *zurni* type, one was similar to E. *beechyi* of the squirrel. Only in one sample, obtained from the shaded area near the spring, was a single oöcyst of *Eimeria* found which it was felt may have come from quail.

In the first 107 samples of soil from Dune Lakes, 16 showed coccidial oöcysts. Most of the positive samples contained a single oöcyst, ten were not sporulated or had degenerated, and two were typical rabbit forms. One sample contained the nesting material and top inch of soil

from a nest which had been inhabited by quail until about one month previous to collection of the sample. Three tests of this material revealed between 60 and 100 oöcysts of *Eimeria* per 2 gram sample. Approximately 250 sporulated oöcysts from this sample were fed to a quail about a month old. This bird had been hatched in captivity at the State Game Farm in Chino, was negative for coccidia for four days prior to feeding with the experimental oöcysts and for 18 days thereafter. On the 11th day after inoculation the bird was placed in a cage with other infected quail and on the 19th day after the original inoculation showed parasites similar to those from the quail in the same cage. Too little is known as yet concerning the life cycles of the quail coccidia to state whether this test was adequate to conclude that the parasites obtained from the soil sample were not quail coccidia but rather from some other species of animal which had used the nest subsequently.

Discussion

In the present paper coccidia were found in fecal material from birds in all areas sampled, and in most the incidence was high but the intensity was low. In the birds from Corning the incidence and intensity of infection were both high. From observations on young quail in captivity it is evident that at least some of the coccidia can prove fatal to the birds heavily infected. Research on chickens and other captive bird species has shown that some species are extremely pathogenic, while others are only mildly or negligibly so. It seems safe to assume that the same will prove true with the species occurring in the quail. Of the five species observed none resembled *Eimeria tenella*, the most severe hemorrhage-producing species which occurs in chickens. From our present data it is impossible to state how much of the coccidia found was of importance pathogenically, or had any effect on the health of the wild birds. It may be that most of the oöcysts observed were *Eimeria* of little pathogenic significance. However, until recently, it was thought by most workers on the basis of the few meager observations which had been reported, that coccidia were not common in wild birds. Our data demonstrate a high incidence in most cases. Further study will be necessary before any statement can be offered on the significance of these findings.

It is impossible at present also to explain the cause of the differences in intensity of infection in various areas as illustrated in Figure 59. The differences in intensity obtained from the various samplings at Bitterwater and Dune Lakes indicate that a seasonal as well as geographical factor is involved. Herman, Chattin and Saarni (1943) attempted to explain their findings at the San Joaquin Experimental Range on the basis of seasonal food habits of the birds, but the demonstration of a similar curve (Figure 60) from the Dune Lakes fecal samples, where the food supply is more or less constant and almost entirely grain throughout the year, can not be explained by the same hypothesis.

The data presented in Table 2 suggest a possible source of error in the methods followed in this study. It is felt that the chief source of error is the possible source of the fecal sample. Not only are coccidia specific as to host, but one species may infect only the caecum, whereas another may infect only the main intestinal tract. Thus, if a bird had a heavy caecal infection and a negative intestine, fecal material from

the caecum would be positive, while if from the intestine the bird would be diagnosed as being uninfected. Mixtures from both sources would account for variations between the extremes. However, it is felt that with the large numbers of samples taken from each area studied, the error would be negligible and at any rate would have no significant bearing on the general conclusions which can be drawn from the data. Further studies, now in progress, which may enable us to differentiate between caecal and intestinal coccidia, will, it is hoped, produce some of the answers to the many questions which can present themselves in any attempt to explain much of the data presented in this preliminary publication.

Numerous investigators studying coccidiosis in poultry have emphasized the importance of contaminated soil in the chicken runs as a source of infection. Patterson (1933) carried out extensive experiments on the effect of environment on *Eimeria tenella* of the chicken. In a review of the literature he points out the general belief that coccidia live for a year or longer in the soil. He cites one investigator who claimed that the oöcysts can remain infective in the soil for four or five years. Johnson (1927) is of the opinion that rapid drying of feces containing oöcysts prohibits sporulation and therefore such material would not be infective. In his experiments Patterson fed the oöcysts to uninfected birds to determine whether they retained their infectivity. The results of his studies would indicate that coccidial oöcysts require moisture and can not withstand decomposition or putrefaction if they are to be kept alive and infective for even as short a period as 23 weeks, which was the duration of his experiments. With oöcysts kept in soil with a 20 per cent moisture content, allowed to evaporate without restoration, and held at atmospheric temperature he failed to infect chickens after 10 weeks, while coccidia kept in soil under "natural" conditions of weathering exposed to direct sunlight caused infections for 10 weeks (the maximum period tested) and when shaded from direct sunlight caused infections for 21 weeks (the maximum period tested). It would seem, therefore, if the same results should hold true for the oöcysts of the coccidia of quail that, except under conditions of severe drying, oöcysts should remain viable in soil for at least a period of several months.

The scarcity of oöcysts of *Eimeria* which might represent the quail coccidia in soil samples from the three areas examined and the extremely small numbers of these oöcysts when present leads us to the opinion that soil contamination is not an important factor in the spread or maintenance of coccidiosis in wild quail. Even during December and January at Dune Lakes and at the San Joaquin Experimental Range, when incidence of coccidia was high in the quail, soil samples collected from spots where quail were most likely to concentrate yielded no appreciable amount of *Eimeria* oöcysts. However, it is assumed from the brief experiments of Herman and Jankiewicz (1942), who showed that the quail lose their infections in the absence of possibilities for reinfection, that infections in wild quail and the increases which are evident from our data are due to repeated reinfection. If contaminated soil is not an important factor the findings can be explained only on the basis of a more direct infection due to the coprophagous habits of the host.

Summary

A total of 3,500 quail fecal samples have been examined for the presence of coccidia. *Eimeria* spp. were found to be present in 19 different areas and 3 game farms. The lowest incidence of infection where more than 49 samples were collected was 19.6 per cent; many areas showed over 50 per cent of the birds to be infected, and several were over 90 per cent.

The intensity of infection varied in different areas as well as in the same area at different times of the year. At Dune Lakes, where periodic samples about a month apart were taken, the highest intensity of infection was at the end of August with another high point in January.

Examination of soil samples from three areas seem to indicate that soil contamination is not an important factor in the maintenance of coccidiosis in wild quail.

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DEER REFUGES UNDER THE BUCK LAW [1]

By F. P. Cronemiller
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Throughout the west, a system of refuges has been considered an essential part of big-game management. The first two decades of the twentieth century found big-game numbers far below those the environment could support. It was generally thought that recovery of the herds from the days of unrestricted hunting was not sufficiently rapid, and that other measures were needed in addition to the closed seasons, bag limits, and sex restrictions that had been placed in effect. This view was strengthened by the feeling that the law-enforcement organizations were insufficient to make the existing regulations fully effective.

During this period an extensive system of big-game refuges was started, on the underlying theory that the animals would increase within them and that they would serve as reservoirs to restock adjoining territory. The theory evidently presupposed—

1. That hunting would keep numbers down in the territory open to shooting.
2. That game would increase within the refuges.
3. That the lack of balance and the resulting population pressure would cause an overflow of animals from the refuges.

Typical of the western states, California has set aside a large number of sizeable big-game refuges during the last 25 years. These are principally for deer, since these animals form over 95 per cent of the State's big-game population. The writer had an important part in recommending many of these areas.

Within the State are 45,000,000 acres of woodland and forest, the bulk of which is big-game range. Over 2,500,000 acres are closed to hunting by established big-game refuges and other protective measures. In addition, there are over 1,700,000 acres within the national parks which are closed to hunting.

Numerous questions have arisen concerning these 4,200,000 acres of refuges and their effect on the deer herds and hunting in the surrounding territory. The marked general increase in the deer population during the period the refuges have been in operation, and the tenacity of the herds in areas subjected to extremely heavy hunting, have led many to believe that the refuge system has been an effective tool in deer management.

State legislation in California permits the taking of male deer with branched antlers only. It is unlawful "to possess . . . female deer, spotted fawn, spike buck, . . . and in District 1¾, forked-horn deer."[2]

Each year for the seven years 1935 to 1941 inclusive, each national forest in the State has kept quite accurate records on individual deer killed. These included antler measurements, actual weights, and location of kill. Antler measurements were taken of over 75,000 animals, actual weights of over 10,000, and the location of each kill was entered on a map as kills were reported. The measurements have served as an

[1] Submitted for publication March, 1943.
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[2] In portions of District 1¾ Rocky Mountain mule deer predominate.

indication of the condition of the crop of animals harvested. The spot maps of the deer kill have served many purposes, an important one being to aid in interpreting the effect of the refuge system.

It was apparently assumed that refuges would maintain deer populations and perhaps increase them within their immediate vicinity. When functioning at their best the deer-kill spot maps would appear

FIG. 61. Map of California, showing refuges, national parks, national monuments.

like that of the eastern part of the Plumas National Forest. In Figure 62, the heavier kill in the vicinity of State Fish and Game Refuges 1-P (established in 1927) and 1-V (established in 1935) could be interpreted as showing their successful operation. A study of these areas on the ground, however, shows that the concentrated kill adjacent to the refuges, which reflects heavier deer populations, is due in part at least to other factors such as quantity of preferred forage species and proximity

or accessibility to desirable winter ranges. In some places the high population or kill within a short air-line distance from the refuge has no relation to it, since the herds are separated by a topographic barrier.

Many refuges were established without much thought as to the food supply available. Game Refuge 2-A in Mendocino and Lake counties, established in 1917, was one of these. It was placed in a timbered area where there was a minimum of suitable forage and a low deer population. After 25 years there is no evidence that the number in the vicinity has increased. As seen in Figure 63, the kill is very low in nearly all of the

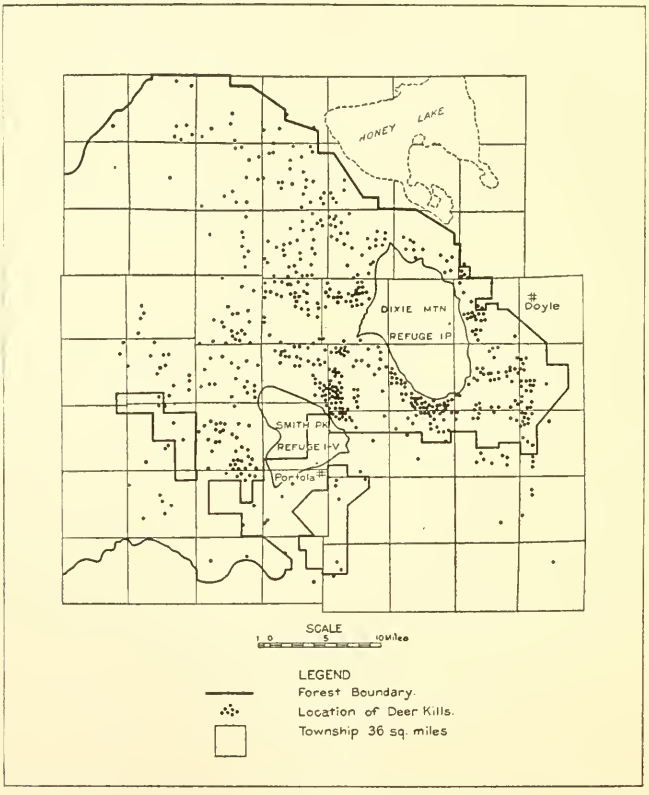

FIG. 62. Spot map of deer kill, Plumas National Forest, 1938.

contiguous area. The areas of heavy kill coincide with the areas of more abundant forage.

Where refuges are established on migration routes, needed protection may be given deer from overshooting or from the deadly methods of the ambuscade. On the other hand, large refuges on summer ranges at the head of migration routes may result in the only territory open to shooting being on these routes. Migrations in the Sierra and Cascades in California start near the close of the hunting season (October 15). If fall storms are early, the downward movement will be within the open season; if late, it will not occur until afterwards. If the early storms are

heavy, the movement will be abrupt and a heavy kill will result in the open territory. As a result, such refuges function differently in different seasons.

Topographic barriers in many cases have partially defeated the purposes of refuges. Boundaries have been made along deep canyons, high, almost uncrossable ridges, large bodies of water, etc. The Huntington Lake Refuge, created in 1931, is an example. Its boundaries include the deep canyons of the San Joaquin River and Big Creek, the high cirque of Kaiser Crest at 9,000 to 10,000 feet elevation, powerhouse penstocks, and Huntington Lake. This refuge was created partly to promote park-like conditions in the highly developed recreational area to the north of Huntington Lake, where vacationists could see and photo-

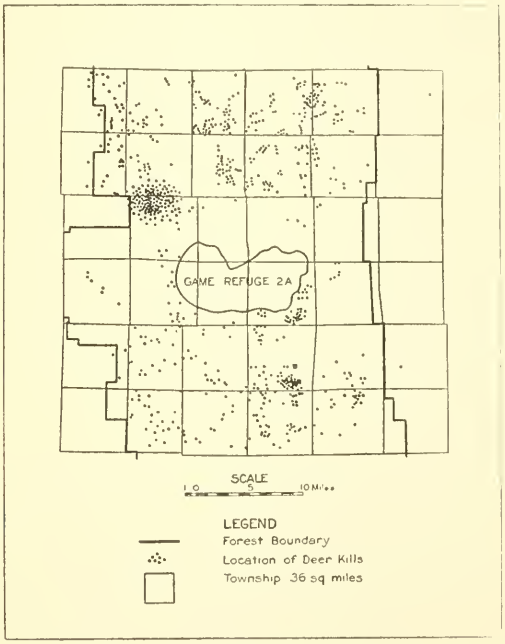

FIG. 63. Spot map of deer kill, Mendocino National Forest, 1938.

graph deer and also be free from the stray bullets of the hunters. Still, had the herds overflowed in accord with the refuge theory, the deer population would have increased in parts of the contiguous area. That this did not occur is indicated by the spot map of the deer kill for the Sierra forest, which is shown in Figure 64.

Refuge 1-K (created in 1917) is similarly bounded; on the south by the deep canyon of Kings River and on the north by the escarpment of Spanish Mountain, 9,000 to 10,000 feet in elevation. The area of heavy kill to the north, indicated in Figure 64, is a separate biotic unit, and these herds bear little relationship to those in Refuge 1-K. Refuge 1-K was abandoned in 1941, and the kill that year in the accessible area, which is the upper or northerly part of the refuge, was much less per unit of area than in the territory to the north, long open to shooting.

The herds of Yosemite National Park have contributed little to sport hunting on the Sierra Forest. The southerly and westerly boundary of Yosemite is to a large extent on legal land subdivisions cutting across natural wildlife units, yet the spot map (Fig. 64) does not indicate that a higher population has been developed in its vicinity by this long-established sanctuary.

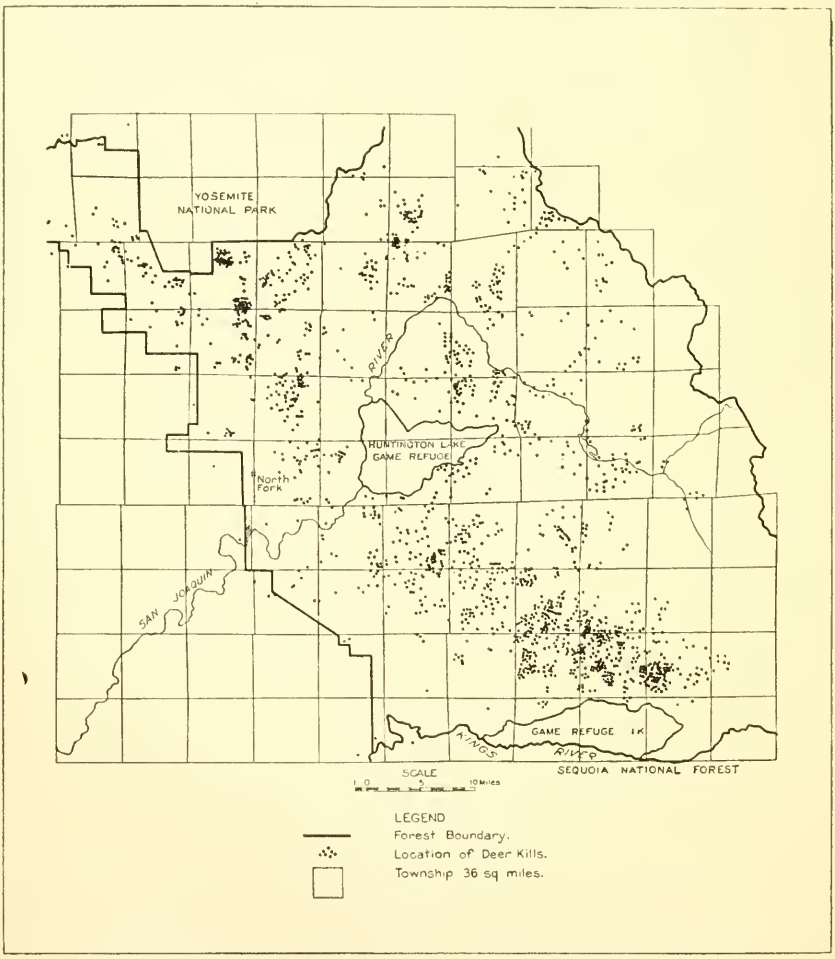

Fig. 64. Spot map of deer kill, Sierra National Forest, 1938.

An inspection of the spot map of deer kill for the Sequoia Forest does not indicate that the large area included in the Sequoia National Park has been of value as the refuge theory would have it. In Figure 65 the circumscribed areas marked "A" are in the better deer range and all within four miles of the north and south boundaries of the park. It would be assumed that within these areas there should be a definite indication of refuge influence if such existed. They contained 185 square miles, and there was recorded a kill of 0.76 deer per square mile in 1940. In an area

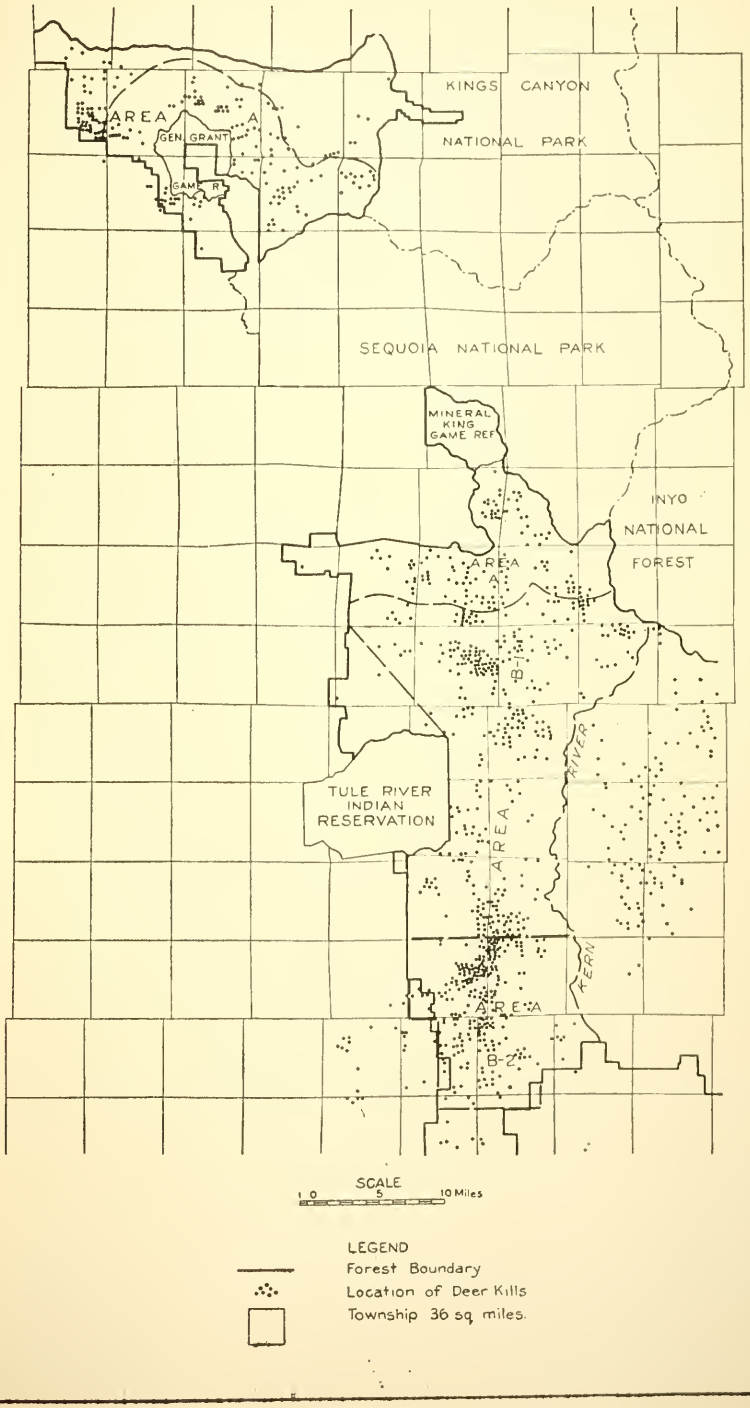

FIG. 65. Spot map of deer kill, Sequoia National Forest, 1940.

more remote from the park (Area B-1), with similar environmental conditions, containing 328 square miles, the kill was 1.03 per square mile. If Area B-2, still more remote, is added, the kill was 1.18. The area to the west of the park is late fall and winter range and not occupied by deer in any great number until the close of the hunting season.

The value of big-game hunting in California normally is recreational rather than as a supplemental food supply. Management therefore considers the "trophy" quality of animals taken. A heavy take of buck deer over a period of years results in fewer of the older age classes being available. The crop then consists mostly of juveniles two or three years of age, small in size, and of insufficient antler development to be termed a

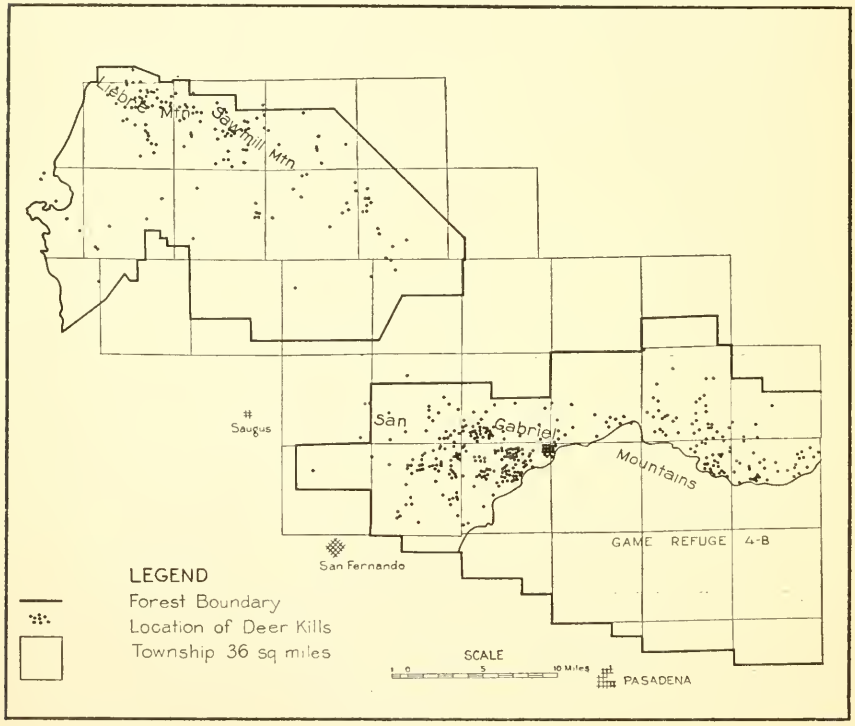

FIG. 66. Spot map of deer kill, Angeles National Forest, 1935.

trophy. An analysis of limited data indicates that the trophy quality may increase in the vicinity of refuges. In Area A on the Sequoia Forest the bucks taken averaged nearly 10 pounds heavier than in Area B and had correspondingly greater antler development.

Area B-2 on this spot map, and others, repeatedly show that high populations are developed and maintained under the buck law away from the influence of a refuge. This is clearly illustrated by comparing two separate units on the Angeles Forest (Fig. 66). The Liebre-Sawmill Mountain area is a mountain range separated from the San Gabriel Mountains by the fairly broad Santa Clara River drainage into which the Mojave Desert intrudes, forming a definite barrier to deer movements. Over one-half of the San Gabriel Mountain portion of this forest is within Game Refuge 4-B. This was created in 1929, partly for the purpose of

reducing human use and thereby increasing the protection of important watersheds from fire. For many years the deer kill was very high in Los Angeles County.[3] Some credited the large refuge as being the management tool that permitted the deer kill to be maintained. Such "off-hand" conclusions were no doubt reached without consideration of the barriers of desert and urban areas between the different hunting areas in the county or without knowledge of the kill from year to year in the vicinity of the refuge.

Studies in this area indicate the herds do not have the mobility of the migrating herds of the north. The few does that have been under more or less continuous observation for periods of several years have a year-long radius of movement little more than one-fourth mile. Known bucks have confined their lifetime movements to a few hundred acres. These movements have been exceeded only by those deer that summer at the highest elevations where deep snows force the animals to somewhat lower elevations for winter. Individual deer definitely have a "home base," and the spread of these deer under minor population differentials is probably negligible.

It can be safely stated that because of the desert barrier the kill on Sawmill and Liebre mountains was not appreciably influenced by Refuge 4-B in the San Gabriels. The territory open to shooting is similar in character on both mountain ranges, yet the San Gabriels contain somewhat better quality deer forage due to the fact that a larger proportion is at a higher elevation. The more succulent forage plants occur above the 4,000-foot contour; in the Liebre-Sawmill mountains only about 10 per cent of the hunting area is above this limit, whereas in the San Gabriels this figure is near 20 per cent.

From 1935 to 1941 inclusive, a total kill of 1,742 deer has been recorded for the Sawmill-Liebre area and 1,145 for the San Gabriel. The average annual kill per square mile was 0.97 and 1.05 respectively. The highest average kill on the Sawmill-Liebre area was 1.43 per square mile (1938) and the lowest 0.68 (1935 and 1941). In the San Gabriel area the highest was 2.17 (1935) and the lowest 0.22 (1941).

The change in deer kill in the two areas over the 7-year period in which records were taken (Table 1) raises another vital question.

TABLE 1

Deer Kill for the Sawmill-Liebre and San Gabriel Areas, 1935 to 1941, Inclusive

Year	*Sawmill-Liebre*	*San Gabriel*
1935	175	337
1936	258	304
1937	325	209
1938	366	145
1939	279	84
1940	165	32
1941	174	34

In the fall of 1937, rangers reported that in excess of 200 deer had died in the Pacoima, Tujunga, and Arroyo Seco drainages in the San Gabriel Mountains. The area in which losses were noted was bisected by

[3] The Angeles National Forest is almost wholly within Los Angeles County.

the refuge boundary, and the focal point seemed to be within the refuge. Posting carcasses in the field indicated an intestinal disturbance which at the time was assumed to result from a poison. The quick onset of the losses and the rapid spread to areas that had supported a large deer population for many years and were remote from orchard sprays and other poisons indicated an epidemic disease was causing the loss. This was borne out by the fact that the losses continued over a three-year period, as reflected in the kill recorded.

The analysis of the maps and records leads to the conclusion that the large refuge area has not maintained the deer population, and has given rise to the question as to whether or not the refuge has been a major factor in causing the catastrophe that has overtaken the herd.

Refuge 4-B is an example of a sanctuary created partly for reasons other than game conservation. The protection of a series of watersheds from fire was a factor in determining its placing and its size, and perhaps crystallized the decision to establish it. Similar action has been taken in other areas of high fire hazard, and still other refuges and parts of refuges have been created in the interest of protecting power installations, highly-developed scientific observatories, and the particular interest of individual landowners. On the other hand, areas within the national forests closed to public use for fire protection under regulations of the Secretary of Agriculture have been effective refuges, where the hunting season does not extend beyond the fire season.

Under the California State Fish and Game Code, areas may be closed to hunting where required for the special protection of game animals. Such action has been taken where extensive brush fires have removed needed protective cover. Deer are often attracted to these areas by the temporary increase in desirable food consisting of succulent sprouts and herbs. The escape cover is eliminated by fire, and a very heavy kill may result unless a closure is effected. After a period of three to five years, cover is partially reestablished, the forage loses its attractiveness, and the concentration is dispersed. The area is then reopened to hunting. Such temporary refuges are effective in limiting the take of the legal males.

In opening refuges, the hunting effort for the first year or two is far above normal. Hunters assume these newly-opened areas offer a better opportunity to secure a deer, and they flock to such areas in large numbers. The result is usually a heavy take but only average success per individual hunter. There is increased hazard to the hunter from stray bullets, and an immediate reduction of the number of legal males to that of the surrounding open territory. For this reason the periodic opening or shifting of refuges does not appear to be an effective tool in deer management, except in the case above cited where the change in the forage results in a dispersal of the animals before the area is opened to shooting.

Discussion

In order to explain why deer refuges have demonstrated so little positive evidence of their effectiveness and have shown much that is negative, their theory must be explored and the inherent characteristics of the animals examined.

1. The breeding potential of deer is high—if realized, it is sufficient to double the size of the herds at least every two years. With herds

averaging over 40 per cent breeding does, and with a doe-fawn ratio of 1 :1.5 at birth, the 500,000 deer in the State could produce 300,000 fawns a year. Yet only 40,000 animals are removed annually by legal hunting. Over 200,000, then, must succumb to disease, weather, starvation, predators, and other causes.

2. Deer are polygamous and promiscuous in their breeding habits. The taking of a portion of the legal males does not interfere with the breeding potential. A study of 2,681 bucks taken on the Angeles Forest during the seven-year period 1935-1941 showed that hunting removed less than 40 per cent of the legal males each year. This is believed to be the heaviest kill in the State. Those who have studied deer herds during the breeding season could not possibly assume that the so-called "barren" doe could be the result of a scarcity of bucks, when the ratio of breeding males to mature females is no lower than 1 to 3 or 4.

3. In only a few instances is there evidence that marked population differentials exist between the refuges studied and adjoining open areas. However, should they exist, there is strong evidence that such conditions do not result in any considerable dispersal from the more concentrated areas. Deer have a definite "home base." This is particularly true under the natural conditions of a refuge. It consists of selected places for cover, feeding areas, watering places, and avenues of escape. Populations may expand until there is a shortage of food, a lower level of nutrition, and less resistance to disease and severe weather. Then there is a natural reduction in the herd to the capacity of the habitat. Such vicious circles are also known to take place in areas open to shooting under the buck law. Should major differences in population exist between adjacent areas similar in character, it can not be denied that some movement may result. The point is that these differentials generally do not exist to a marked degree.

Refuges to a certain extent serve as sanctuaries for the legal males during the hunting season, but not in all cases. After the Cleremont Refuge in the Plumas Forest was abandoned in 1935, the kill within that area was no higher than that in the surrounding territory that had been open for many years. No concentration was noted in the area that had been included in Refuge 1-K, when it was opened in 1941. On the other hand, on two different areas on the Modoc Forest that were opened after a number of years of closure, a concentration of legal males was found. The number of other deer, however, was low.

4. Refuges with flexible control are usable for protecting particularly vulnerable herds, such as those whose escape cover has been destroyed by fire, herds concentrated on migration routes, or plantings in underpopulated areas. There are possibilities in the use of refuges to improve the trophy quality in local areas where the existing season and bag limit is insufficient to allow the herds to produce animals of desirable size. In addition, they can be used when other uses of land preclude hunting.

Conclusions

As a result of the study it is concluded:

1. That deer refuges under the California buck law are of value where visual recreation is of greater importance than hunting.

2. That they are of value in areas of concentrated human use requiring the removal of the hazard of stray bullets.

3. That they are of value to furnish needed protection on well-defined migration routes, and in such localities to promote better sport.

4. That they are of value to furnish needed protection to deer on certain burned-over areas where escape cover is removed and concentrations are heavier because of a temporary increase in the amount of succulent feed.

5. That the establishment of a refuge as a means of reducing human use of an area, such as for the purpose of protecting a watershed from fire, is not meeting an issue squarely. Obviously the answer in this case is to establish an open season when human use will not be a threat to the major values and at a time when the animals are in a satisfactory condition for taking.

6. That under a buck law, refuges temporary in character may be of value in special problem areas, to prevent a heavy take of bucks and particularly to maintain the sporting values of trophy hunting.

7. That the use of a refuge as a game-management tool presupposes improper management of the areas open to shooting—this to the extent that hunting reduces the herds excessively or interferes with the breeding potential.

8. That refuges have not increased hunting opportunities but have resulted in a reduction in the take approximately equivalent to their proportionate area.

9. That retention by the Legislature of authority to establish, adjust, and abolish refuges precludes effective management and lends permanency to errors inherent in a system of fixed refuges and to the problems that develop within them.

10. That deer refuges under the buck law should be re-examined in the light of present-day knowledge and given a general overhaul.

GOLDEN TROUT PROPAGATION IN CALIFORNIA[1]

By George McCloud
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California Division of Fish and Game

The native golden trout of California were originally found only in three small streams: Soda Creek, flowing into the Kern River from the west, and Golden Trout Creek and the South Fork of the Kern, flowing into the same river from the east.[2] Prior to 1918 the only planting and distribution of these fish was effected by catching the young and adults from their native streams and transporting them to barren waters throughout the high Sierra. The first work of this kind was done by the early cattlemen who ran their stock in the Kern River watershed during the summer; later it was carried on by the California Fish and Game Commission and by private individuals of the San Joaquin Valley. The wardens took an active part, particularly A. D. Ferguson, who was in charge of the Fresno office, and Deputies Sam Ellis, F. A. Bullard, E. W. Smalley and O. P. Brownlow (1908-1916).

The first attempt to propagate golden trout in California was made about 1910. The U. S. Bureau of Fisheries (now part of the U. S. Fish and Wildlife Service) sent the late G. H. Lambson to Volcano Creek to collect eggs, but the trip was begun too late in the season, and the fish had already spawned. In 1917 the California Fish and Game Commission tried to collect eggs from the Cottonwood Lakes in Inyo County, near Mt. Whitney, where the golden trout had been introduced by cattlemen many years earlier from Mulkey Creek, a tributary to the South Fork of Kern. Frank Shebley, then Superintendent of the Mt. Whitney Hatchery, and Ed Ober of the Patrol Department, were detailed on this mission. In this case again the start was made so late that the fish had completed spawning before operations could commence. One or two late females from which eggs were taken and sent to the hatchery must have been overripe, because the eggs failed to hatch.

Early in 1918, W. H. Shebley instructed me to use every effort to obtain golden trout eggs from the Cottonwood Lakes. With the previous failures in mind, I laid my plans well in advance. To avoid any possibility of being too late, I made my first reconnaisance trip to the lakes in March, and found them frozen solid with about six feet of snow on the ground. On my next trip, May 15th, I found them still frozen, with about the same amount of snow; but I also found a few males with milt at the outlet of the lowest lake.

On June 1st two men were sent to Cottonwood Lakes to open camp and to put in traps, holding tanks, etc. At that time all material had to be carried on pack animals from Lone Pine, a distance of 26 miles, and a climb of 7,000 feet. The start was made none too soon, as shortly

[1] Submitted for publication, April, 1943.

[2] Golden Trout Creek was formerly called Whitney Creek and Volcano Creek. Its trout was originally set up as a distinct species, *Salmo roosevelti*, but it is now generally accepted that this is only a color phase of *Salmo aguabonita*, to which species all of the golden trout from east of the Kern River are now referred. It is this fish which has furnished most of the stock for transplantation. The Soda Creek form is still considered a separate species, *Salmo whitei*.—*Ed.*

after the first of June we caught spawning fish in our traps in the lower lakes. At this high altitude—11,000 feet—the trout begin to go out of the lakes into the small streams before the ice leaves and almost before any sign of spring can be seen. Since these fish go downstream as well as up to spawn, traps at the Cottonwood Lakes were operated in both the inlets and the outlets. The first egg-take was made on June 13, 1918. Initiating a practice which has been followed with excellent results ever since, the eggs were held overnight in cans in a small stream between two of the lakes, and the next day carried by pack mule to Lone Pine, and from there to the Mt. Whitney Hatchery near Independence, 20 miles farther north, by motor truck.

During the first years, our crew at Cottonwood Lakes had to live in the open. Camping out at this elevation in May and June is no picnic,

Fig. 67. The Cottonwood Lakes country.

especially when working in ice-cold water all day. In 1930 our bureau constructed a small sheet-iron cabin with cement floor, equipped with cook stove, table, chairs and cots. In 1934 it erected two small hatching troughs to eye part of the eggs at the lakes, with the hope that this might give better results than the transportation of green eggs to the hatchery. A two-year trial showed no advantage in this system and it was discontinued.

An important improvement in the general situation has been the construction of a good automobile road from Lone Pine to two miles beyond Carol Creek at the base of the mountain. This cuts the distance to be made by pack animal to about 16 miles, which can be covered in four or five hours by saddle horse.

The collection of golden trout eggs was very successful in the Cottonwood Lakes from 1918 through 1938, the desired number, approximately

1,000,000 annually, being easily taken in most of those years (see Table 1). In 1939 the take suddenly dropped to only 320,000 eggs, and in 1940 and 1941 fell still farther. The reasons for this are uncertain; a large anglers' catch of spawned-out fish schooling near the inlets in 1938, together with disease which was undoubtedly present in 1938 and 1939, may have been factors. In view of the low returns, and of the reduction in manpower due to the war, egg-taking operations were not attempted in 1942 and 1943.

Other changes have been noted in the golden trout of Cottonwood Lakes since the beginning of our work there. Fish were probably not as plentiful in 1918 as they have been in some years since, and the number of fishermen has increased in the ratio of something like 20 to 1. In the two lower lakes the fish are now about the same size as in 1918. In Lake Number 3, after a gradual decline in size associated perhaps with a large population brought about by closure to fishing, there has recently been a marked increase in size. This could easily be due to the decrease

FIG 68. Trapping golden trout spawners in Cottonwood Lakes, June 25, 1933.

in the number of fish in the lake in the last four years. In 1933 the Lake Number 3 spawning traps caught 4,889 trout, in 1941 they caught 834. In 1933 they averaged eight inches, in 1940 they were reported to average 11 inches.

In 1918 Lakes 4 and 5 contained a few fish—not more than seven or eight hundred adults combined, I should estimate—of large size,

TABLE 1

Golden Trout, 1918-1943—Cottonwood Lakes Egg-Collecting Station—Mount Whitney Hatchery

Date	Egg take	Local plants	Shipped	Destination
1918	520,000	145,000	5,000 fish 25,000 fish 225,000 fish	San Gabriel River Santa Ana River McCloud River-Truckee River*
1919	965,000	410,000	252,000 eggs	Tahoe Hatchery
1920	782,000	567,000	28,000 fish	Los Angeles County
1921-22-23—Not operated				
1924	490,000	412,000		
1925	490,000	430,000		
1926	500,000	425,000		
1927	500,000	300,000		
1928	690,000	530,000	50,000 eggs 25,000 eggs 5,000 eggs	Bozeman, Montana Caledonia, New York New York City Aquarium
1929	1,060,000	766,000	50,000 eggs 25,000 eggs	Bozeman, Montana Tahoe Hatchery
1930	1,250,000	1,200,000		
1931	975,000	745,000		
1932	910,000	765,000	50,000 eggs 5,000 eggs 80,000 eggs 10,000 fish	Alpine Hatchery Steinhart Aquarium Tahoe Hatchery Redding, Shasta County
1933**	1,015,000	902,500	15,000 eggs	England
1934**	1,762,350	1,590,980	100,000 fish	Tahoe Hatchery
1935	1,380,900	858,480	27,520 eggs 15,000 eggs 25,000 eggs 50,000 eggs 50,000 eggs 25,000 eggs 50,000 eggs	Hot Creek Hatchery Steinhart Aquarium Springville, Utah Wyoming Yosemite Hatchery Montana Tahoe Hatchery
1936	1,204,000	611,544	25,000 eggs 100,000 eggs 50,000 eggs 25,000 eggs	Hot Creek Hatchery Yosemite Hatchery Tallac Hatchery Enemclaw, Washington
1937	1,047,625	666,374	90,000 fish 10,000 eggs 20,000 eggs 25,000 eggs	Tahoe Hatchery Hot Creek Hatchery Denver Fish and Game Iowa State
1938	1,171,650	664,288	200,000 eggs 25,000 eggs 100,000 fish	Yosemite Hatchery Hot Creek Hatchery Tahoe Hatchery
1939	320,000	208,000		
1940	108,000	87,000		
1941	271,000			
1942-43—Not operated				

NOTES—

"Local Plants." These fish were planted directly from the Mt. Whitney Hatchery in Inyo, Mono, Tulare, Fresno, Madera and Alpine counties. The general policy has been to confine the planting of golden trout insofar as possible to areas close to and similar to their native habitat.

"Eggs" in "Shipped" column signifies eyed eggs.

* These fish were shipped on the State fish car and were assigned to the McCloud River and Truckee River. The fish for the McCloud River were first taken to the Sisson Hatchery, and later planted from that station.

** During 1933 and 1934 the egg-take figure shows only 80% of the actual take. The method used during this period was to deduct 20% to account for unfertile eggs and other loss in the hatchery.

running as high as five and six pounds. In 1933 they produced 2,600 spawners, but the average length was only 11 inches. In 1941 the number of spawners was only 226. The total catch in the spawning traps of all the lakes was 8,900 in 1933; in 1940 it was only 740; in 1941, 1,429. The nearby lakes on the South Fork of Cottonwood Creek, where no egg-taking has been done, also suffered a drop in population in 1938, in which year hundreds of dead and dying fish were seen in these waters.

During our first years of golden trout culture we had considerable trouble with disease, but after several years of experience this was eliminated. A summary of golden trout propagation at the Mt. Whitney Hatchery is given in Table 1.

THE RELATIONSHIP OF FISH TO THE CLEAR LAKE GNAT, IN CLEAR LAKE, CALIFORNIA[1]

By Arthur W. Lindquist, Christian C. Deonier and J. E. Hancey
Bureau of Entomology and Plant Quarantine
Agricultural Research Administration
U. S. Department of Agriculture

In the study of the biology and control of the Clear Lake gnat (*Chaoborus astictopus* D. & S.) attention was given to the role that the various species of fish play in the natural control of the pest. *Chaoborus* is the dominant insect found in the lake, and bottom samples have yielded as high as 1,000 larvae per square foot (Lindquist and Deonier, in press). Emerging adults have averaged 535 per square foot over the lake during a season (Lindquist and Deonier, 1942.2).

Fig. 69. Clear Lake as viewed from the northeast shore.

Clear Lake is located in Lake County, California, and has an area of approximately 40,000 acres (Fig. 69). The shore is regular, with few bays and coves. The greatest depth at zero Rumsey gauge reading (a gauge for determining the lake's level) has been found to be 27 feet in the upper portion and 50 feet in the lower portion.

It appeared that fish would have access to all stages of the gnat and that examination of the digestive tract would yield information on their food habits. Seventeen species of fish were taken in Clear Lake (1938-41) and are listed herewith. The common names used are in accordance with the proposals of the Committee on Common and Scientific Names of

[1] Submitted for publication June, 1943.

Fishes of the American Fisheries Society. Identifications were made by the junior author according to the keys of Evermann and Clark. Some identifications were verified by Dr. Paul R. Needham.

Ictalurus catus (Linnaeus) White or Fork-tail catfish.
Ameiurus nebulosus (Le Sueur) Brown bullhead or Square-tail catfish.
Gambusia affinis (Baird & Girard) Mosquito fish.
Helioperca incisor (C. & B.) Bluegill sunfish.
Pomoxis sparoides (Lacepède) Black crappie or Calico bass.
Archoplites interruptus (Girard) Sacramento perch.
Lavina exilicauda (Baird & Girard) Hitch.
Pogonichthys macrolepidotus (Ayres) Split-tail.
Cyprinus carpio (Linnaeus) German carp.
Huro salmoides (Le Sueur) Large-mouth black bass.
Apomotis cyanellus (Rafinesque) Green sunfish.
Orthodon microlepidotus (Ayres) Blackfish.
Siboma crassicauda (Baird & Girard) Sacramento chub.
Ptychocheilus grandis (Ayres) Squaw fish.
Catostomus occidentalis (Ayres) Sacramento sucker.
Cottus gulosus (Girard) Sculpin.
Hysterocarpus traski (Gibbons) Freshwater viviparous perch.

Analyses of Digestive Tracts

The digestive tracts from 355 fish comprising 10 species have been examined. These are summarized in Table 1. Although records were made of various food contents of the digestive tract, only the *Chaoborus* contents, which normally constitute the main item, will be discussed. The numbers of the various stages of this insect could not always be counted, but fairly accurate estimates were made. The stomachs of many fish were empty, but the presence of *Chaoborus* could be detected in the intestinal tract by the chitinous remains of adults, larvae and pupae.

TABLE 1

Data on Analyses of Digestive Tract Contents of Fish in Clear Lake, California. Intestines Are From Same Fish of Which Stomachs Were Examined

Species	Dates	Stomach			Stage of Chaoborus eaten	Intestines		
		Number examined	Number containing food material	Number containing Chaoborus		Number examined	Number containing food material	Number containing remains of Chaoborus
Fork-tail catfish	Aug. to June	139	82	37	All stages	110	79	66
Square-tail catfish	Nov., Jan., April	35	13	10	Larvae	35	35	35
Mosquito fish	July, Aug., Sept.	8	8	8	Adults and eggs	8		
Bluegill sunfish	June, Sept.	39	38	21	All stages	3	3	3
Calico bass (Black crappie)	June, Sept.	12	8	3	Larvae and pupae	9	6	4
Sacramento perch	June, Sept.	17	14	5	Adults, larvae, pupae	12	3	2
Hitch	June, Sept.	32	22	8	Eggs in small specimens	28	22	9
Split-tail	June, Aug., Nov.	31	22	10	All stages	17	15	9
German carp	June, Aug., Sept.	28	19	14	Eggs and adults	24	22	14
Large-mouth black bass	June, Sept.	14	11	0	None	4		

Fork-tail catfish. One of the heaviest feeders on *Chaoborus* larvae and pupae is the fork-tail catfish. It also feeds heavily on adults, but in some cases it appears that the adults are spent females which died on the water after oviposition in the evening. An estimated 5,000 adults were found in one stomach. The greatest number of larvae found was 1,076 in the stomach of a 9-inch fish. The largest number of pupae recorded was 195. The intestines are frequently packed, and estimates of thousands of larval remains have been made in 8 to 12-inch fish. Of the 82 stomachs that contained any material, 45 per cent of them contained *Chaoborus*. Of the 79 intestines in which food was found, 83 per cent of them contained *Chaoborus* larval and pupal remains. The negative characteristic of this fish, in so far as gnat control is concerned, is its fondness for the small fish that are desirable gnat feeders.

Square-tail catfish. This fish is most active during the winter months and consumes great numbers of larvae. The greatest number of larvae

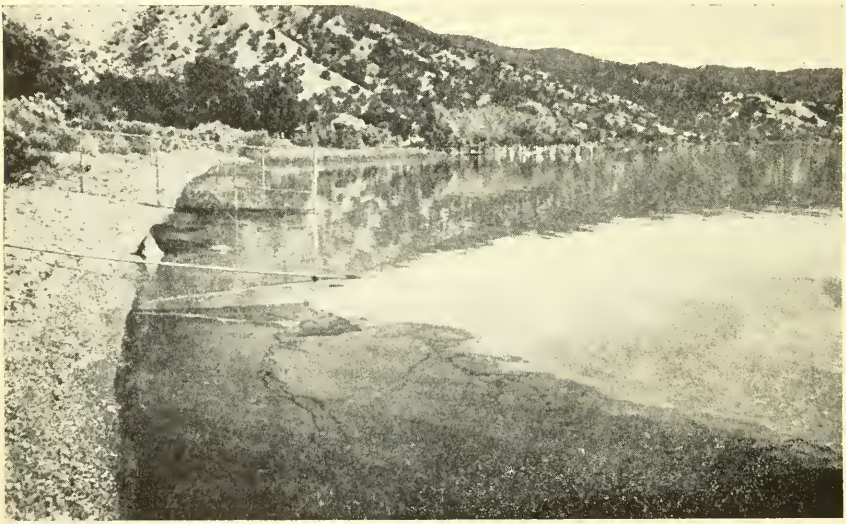

FIG. 70. Heavy concentration of *Chaoborus astictopus* eggs along shore.

found in a stomach was 392, while several thousands have been indicated in the intestines of a single fish. Nearly 77 per cent of the stomachs containing food had *Chaoborus* larvae, while 100 per cent of the intestines showed larval remains. This species is very valuable as a consumer of *Chaoborus*, and no program of fish manipulation should be instituted which might decrease the population of the catfish.

Mosquito fish. The *Gambusia* lives close to shore and other sheltered spots, such as beds of tules and other aquatic plants. Its food apparently consists largely of adult gnats and eggs. It seldom ventures into deep water where the larvae and pupae are plentiful. In the evening and early morning it is observed feeding on adult female gnats alighting on the surface of the water. This species feeds on gnat eggs which float in compact drifts on the water surface as shown in Figure 70 (Lindquist & Deonier, 1942.3). Specimens have been examined in which the entire

digestive tract was packed with these eggs. *Gambusia* does not appear in numbers until the latter part of the summer.

Bluegill sunfish. This fish also feeds heavily on ovipositing female gnats close to shore. A stomach from a 2¾-inch specimen contained 356 adults and another of the same size had 220 adults. One specimen had eaten 87 *Chaoborus* larvae. Eggs were frequently found in the digestive tract.

Calico bass. This species is a game fish, but the stomachs of 3, or 38 per cent of those having food material, contained *Chaoborus* larvae and pupae. One specimen had 151 pupae and 207 larvae in its stomach.

Sacramento perch. This game fish is moderately abundant and apparently feeds considerably on pupae as well as on larvae. In the five fish in which the stomachs contained gnat material, one-third of the total *Chaoborus* recorded were pupae. The largest number of larvae found was 212.

Hitch. The young of the hitch, when 2 or 3 inches in length, are found in association with the bluegill sunfish close to shore, where they consume ovipositing gnats. One stomach contained 40 adults. The digestive tract is frequently packed with *Chaoborus* eggs. Thirty-six per cent of the stomachs and 41 per cent of the intestines in which food material was found contained some stage of *Chaoborus*. As the young hitch grow they move farther out from shore and become plankton feeders. Few *Chaoborus* have been found in the large hitch.

Split-tail. This species is usually abundant and it feeds heavily on all stages of the gnat. It starts its predatory career on *Chaoborus* as small fingerlings and apparently keeps it up throughout life. The young feed on ovipositing females in the evening and also consume myriads of eggs in the egg drifts. The stomach of a 2¼-inch specimen contained an estimated 46,000 eggs. The larger fish taken in November contained up to 400 larvae in the stomach. Several hundred have been estimated in the intestines. Forty-five per cent of the stomachs containing food had various stages of *Chaoborus*. The young of this fish are used for bait fishing and are usually abundant, but during 1941 very few specimens were taken by anyone. Some factor had upset the productivity of the species. Although this species is not considered a desirable food fish, its importance in natural control of the gnat should be considered in the formulation of any regulations regarding commercial seining.

German carp. The carp apparently contributes to natural control of the gnat. The food in its digestive tract is difficult to study because of the mixture of plant tissue and detritus. Large schools of the carp have been observed sucking in the surface film. At times this film is composed of millions of *Chaoborus* eggs; at other times of pupal exuvias, adults, and algae. The digestive tract contains myriads of adults. One 11-inch carp had a record number of 40,000 specimens, most of which were probably spent females. Larvae are frequently found in the digestive tract, but it is doubtful if these fish feed heavily on them. There is no doubt but that carp prey heavily on eggs.

Large-mouth black bass. Of all the species in the lake the black bass is probably the least important in natural control of the gnat. No evidence

of *Chaoborus* was found in the digestive tract of 14 specimens, although the young bass may feed on gnats. Older bass feed heavily on the various species of small gnat-eating fish. The toll of small fish exacted by the bass must be very large.

Notes on the Abundance of Fish

There are at times perhaps millions of fish in Clear Lake. Their total consumption of eggs, larvae, pupae, and adults of *Chaoborus* appears to be enormous, yet it is not sufficient for adequate natural control. The wintertime feeding by fish is very valuable because during this season the *Chaoborus* do not reproduce. The decrease of larvae from a peak in October to a low in May as determined by systematic bottom samplings was an annual occurrence. The larval population was 24.7 per cent less in May, 1939, than in October, 1938. Decreases for the corresponding periods in succeeding years were: 1939-40, 28.2 per cent; 1940-41, 41.7 per cent; 1941-42, 62.7 per cent (Lindquist & Deonier, in press).

Carp have at times been present in enormous numbers. Commercial seining has been carried on for a number of years, and reports indicate that hundreds of tons have been taken.

Other indications of the fish population is the occasional epidemic of dead fish. They have been reported piled up on shore in drifts 1 foot high and several feet wide. Our observations showed thousands of fish on the shoreline during the spring and summer of 1940. The spawning runs up the creeks of split-tails and hitch give some indication of the great numbers in the lake. Tens of thousands of split-tails and hitch have been observed moving in a solid mass up a small creek only 4 feet wide. Evidence of a great catfish population is indicated by the many tons taken by illegal fishermen.

It has been stated that gill nets give an indication of fish abundance in different lakes, but no doubt a great number of net catches are required for worthwhile evaluation. During August 1938, a 125-foot net, 6 feet deep, with meshes of 5 different sizes (1 inch to 3 inches bar measure), was used a total of 165 hours. The average take per hour was 2.1 fish for a total of 346. The split-tail was indicated to be the most abundant (more than 3 times its nearest competitor); then, following in order, the hitch, carp, fork-tail catfish, and Sacramento perch. The mesh may have been too small to yield true proportions of carp, and there is reason to believe that the large-mouth black bass is more abundant than the catches indicate. During June, 1940, the same size gill net was used again for 165 hours but only 98 fish were taken. During May, 1941, the net was operated a total of 141 hours but only 19 fish were taken. One set of 16 hours in October, 1941, yielded 16 fish. Two sets for a total of 33 hours in January, 1941, yielded 12 fish.

Relations of Chemistry of Water to Fish Population

In table 2 are given the chemical analyses of the lake water during 1940 and 1941. The content of dissolved oxygen was determined by the Rideal-Stewart modification of the Winkler method (American Public Health Association and American Water Works Association, 1939). The dissolved oxygen of the surface water varied from 4.4 to 12.0 p.p.m. In the bottom water it varied from 1.7 to 11.0 p.p.m. On June 27, 1940, the

bottom water had a dissolved oxygen content of 1.7 p.p.m., which is dangerously low for some species of fish. It is believed that the stagnant condition existing during June was responsible, in part at least, for the many fish which were dying. It is believed that a depleted fish population will materially reduce the natural control of *Chaoborus* and that no steps should be taken that will alter the water chemistry so that it will be inimical to the various species of fish.

TABLE 2

Chemical Analyses of Water at End of Pier (Except as Indicated). Water Depth 4 to 10 Ft.

Date	Dissolved oxygen, p.p.m.		Free carbon dioxide, p.p.m.		Phenolphthalein alkalinity, p.p.m.		Methyl orange alkalinity, p.p.m.		Temperature, °F., of water sample	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
June 10, 1940	9.0		0		5.5		131		84	
June 26, 1940[1]	7.0	3.1	0		12	0	132	134	80	77
June 27, 1940[1]	4.4	1.7	0	8	7	0	137	137	79	75
June 28, 1940[1]	6.2	2.3	0						77	75
June 29, 1940[1]	5.1	4.5							77	76
June 20, 1940	6.0	6.0		0		6.0		133		80
Nov. 27, 1940	5.7	4.9	1.0	3.0	0	0			56	57
Dec. 2, 1940	3.3	5.7	6.7	8.0	0	0			55	53
Dec. 17, 1940	8.5	6.3			0	0	144	140	48	48
Jan. 14, 1941	8.3	8.0	3.0	2.5	0	0	0	0	48	48
Feb. 6, 1941	8.1	8.3	2.0	1.5	0	0	0	0	48	48
Mar. 15, 1941	12.0	11.0							62	58
Mar. 29, 1941	9.5	9.3	1.0	1.0	0	0	0	0	56	56
Dec. 2, 1940[1]	6.3	5.1	5.0	5.5	0	0	160	150	56	53
April 17, 1941	9.0	8.7	2.0	2.0	0	0	0	0	56	55
May 16, 1941	8.7	8.0	0	2.0	0	0	90	100	76	66
June 19, 1941	8.0	7.2	1.0	2.0	0	0	100	110	70	68
July 15, 1941	8.7	8.0	0	0	9	8	85	95	84	81
July 15, 1941[1]	8.0	7.1	0	0	8	5	100	100	82	80
Aug. 14, 1941	7.0	6.8	Trace	Trace	0	0	110	110	82	80
Aug. 14, 1941[1]	6.5	6.0	1.5	3	0	0	110	120	78	76
Sept. 16, 1941	10.5	7.3		1.0	0	0			84	73
Sept. 16, 1941[1]	7.4	7.0			0	0	0	0		

[1] Analyses of water ½ mile off shore; water depth 18 to 25 ft.

Summary

Seventeen species of fish taken in Clear Lake are listed. The digestive tracts from 355 fish comprising 10 species were examined. All stages of *Chaoborus* were found in 9 species of fish, but it is believed that all species feed on this insect at some time during their life. The fork-tail catfish, square-tail catfish and split-tail are important feeders on all stages of the gnat. As many as 1,076 larvae have been found in the stomach of a 9-inch fish, while several thousands have been estimated in the intestine. Nearly 77 per cent of the stomachs of the square-tail catfish that contained food material had *Chaoborus* larvae, while 100 per cent of the intestines showed larval remains.

Indications of abundance of various species of fish were sought from gill net catches, spawning runs, commercial seining, and illegal fishing. Clear Lake apparently harbors an enormous fish population.

Data on the water chemistry are given.

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JAMES MOFFITT

1900-1943

James Moffitt lost his life in an airplane crash at Dutch Harbor, Alaska, on July 2, 1943, while serving as Lieutenant with the air forces of the United States Navy. He leaves an empty place in the lists of those working with and for wild animals which will be hard to fill. He combined the best qualities implicit in the words "amateur" and "professional." His love of the outdoors, his eagerness to share its pleasures with his friends, his warm sense of fair play, made him the ideal sportsman. As a zoologist, his capacity for careful observation and painstaking study gave him high rank, and made him, among other things, a recognized authority on the wild geese of North America. He was able to inspire others with his own keen enthusiasm for the work in which he was interested. He had the vision to understand the broader values and relationships of problems which might have seemed merely isolated phenomena. The annual census of the black brant wintering in California, which he originated and with the help of others carried on for twelve successive years until interrupted by the war, stands as the most important long-range survey of bird populations in this part of the world.

He was born March 21, 1900, the oldest son of Dr. and Mrs. Herbert C. Moffitt. After early education here and abroad, he entered the University of California in 1917, but left to enlist in the Navy at the age of eighteen. Returning to civilian life after the first war, he did not go back to the University, but continued his study and collection of birds. After some years spent in business with the firm of Blake, Moffitt and Towne, he joined the staff of the California State Division of Fish and Game, and was for a while editor of this magazine. In 1936 he was appointed Curator of Birds and Mammals in the California Academy of Sciences. He was a director of the National Audubon Society, and past president of the Audubon Society of the Pacific. Immediately after Pearl Harbor he volunteered for the second time in the service of his country; was commissioned Lieutenant in the United States Naval Reserve in March, 1942; and was assigned to active duty shortly thereafter. He is survived by his widow, Elizabeth Schmiedell Moffitt, and his daughter, Alice Moffitt Gatterdam.—*Brian Curtis, Editor, California Fish and Game.*

EDITORIALS AND NOTES

AN OUTBREAK OF MYCOTIC PNEUMONIA IN MALLARDS

Just after the opening of the duck hunting season in October, 1941, a disease epidemic occurred among mallards in Modoc County. Warden Don Davison estimated between 300 and 350 mallards died within a two or three week period. No further cases were observed subsequently. Four dead birds were sent to the laboratory by Davison during the height of the outbreak. Autopsy revealed extensive destruction of the lungs with a greenish mold which was caused by the fungus *Aspergillus* sp. Lung involvement by these organisms is usually referred to as mycotic pneumonia.

Sick and dead ducks were found only in a limited area along the South Fork of the Pit River between Alturas and Likely, involving the side wash just south of Fitzhugh Creek. In a forty-acre tule marsh here, and especially in the central ten acres thereof, most of the infected birds were concentrated. Only mallards were affected. The epidemic subsided as rapidly as it had begun.—*Carlton M. Herman, Bureau of Game Conservation, California Division of Fish and Game, May, 1943.*

A RECORD YELLOWTAIL

An exceptionally large yellowtail, *Seriola dorsalis* (Gill) was delivered by the purse seiner "Venus" to the Franco-Italian Packing Company, Los Angeles Harbor, on June 8, 1943. This specimen, caught off Guadalupe Island on a handline, baited with mackerel, weighed 67 pounds when received at the cannery, and measured 58¼ inches in total length.

A previous record given by the Tuna Club of Santa Catalina Island is 60½ pounds for a yellowtail taken on a rod and reel in 1908.—*Gerhard Bakker, Jr., Bureau of Marine Fisheries, California Division of Fish and Game, June, 1943.*

TWENTY-FIVE YEARS AGO IN CALIFORNIA FISH AND GAME

The first paper in the October, 1918, issue of California Fish and Game was E. C. Starks' "The Flatfishes of California," a continuation of his valuable series on our native fishes. In conjunction with this appears a short dissertation by him "On Common Names of Fishes." He points out that confusion has arisen because of the lack of any rules for common names such as govern the application of scientific names, and also because of the tendency of pioneers to give to unknown fishes in new territories the names of more or less similar forms in their original homes. He speaks specifically of marine fishes, but the same situation exists with regard to our freshwater species. To mention only one case the "Sacramento Pike" (*Ptychocheilus grandis*), a predatory rough fish of little value for which no fishing license is required, is often called "whitefish"; at the same time we have a true salmonoid whitefish, the

Rocky Mountain Whitefish (*Prosopium williamsoni*), in the Truckee and other east slope rivers, which is nonpredatory, of food value, and for which a fishing license is required. Further, the Sacramento Pike does not belong to the pike family at all, but to the minnow or carp family. It is for this reason that the Committee on Common and Scientific names of Fishes of the American Fisheries Society has proposed for it the official designation "Sacramento Squawfish." It is to be hoped that when this committee has finished its work and published its report we can begin to eliminate some of the confusion in the common names of fishes, both marine and freshwater.

One of the leading editorials twenty-five years ago discussed "The Dangers of the Bounty System." At that time half the counties in the state paid bounties on predatory animals, among which were included rabbits, blue-jays and buzzards, and the sum so expended in the preceding fiscal year had come to over $53,000. The editorial raises the question as to whether the results achieved justified the expenditure of so much money, and points out the difficulties of distinguishing between bounty-free and bounty-paying species, as well as the danger of fraudulent transportation of predator remains into high-bounty areas. It is because of these weaknesses that the whole bounty system, once a widespread favorite throughout the states of the union, has been very greatly curtailed. The State of California now pays a bounty on only one predator, the mountain lion—$30 on females and $20 on males; and about a dozen counties pay bounties ranging from 50 cents to $10 on bobcats and coyotes, plus in some cases a supplement to the state bounty on lions. It is generally felt that the bounty system has proven satisfactory for mountain lions, but that for the other predatory species the paid trappers and hunters are more effective.—*Brian Curtis, Editor*, California Fish and Game.

IN MEMORIAM

CURTIS LEE BUNDOCK

It is with regret that we announce the death of Warden C. L. Bundock, at his home in Oakland on June 5, 1943. He was 43 years of age.

Warden Bundock was the son of J. L. Bundock, who served as a warden with the Division of Fish and Game from 1910 to 1934. Much of his early training in law enforcement was under the teaching of his father. "Bun," as he was affectionately known by his associates, entered the service on December 1, 1925, and he retired on disability April 7, 1943.

For over a year preceding his death, Bundock had suffered from an ailment from which apparently there was no relief. During this period his unfailing cheerfulness gained the respect of all who came in contact with him. He leaves a mother, wife and daughter who reside at 5439 Camden Street, Oakland, and to whom we wish to extend our sincere sympathy.—*L. F. Chappell, Chief, Bureau of Patrol, California Division of Fish and Game, June, 1943.*

ALVIN GRANSTROM

Alvin Granstrom passed away at his home in Yuba City on July 21, 1943.

Warden Granstrom entered the service as a game warden in September, 1929. He served in this capacity in various parts of the State and since 1938 has been stationed at Yuba City. He was regarded very highly by the bureau as a willing, efficient and energetic law enforcement officer. We, of the department, will miss him.

Al belonged to the Masonic fraternity and was also a member of the American Legion under whose joint auspices the funeral was held at Yuba City on Saturday, July 24th.

He is survived by his wife and daughter to whom we extend our sincere sympathy.—*L. F. Chappell, Chief, Bureau of Patrol, California Division of Fish and Game.*

CHARLES R. LOVE

We regret to announce the death of Warden Charles R. Love which occurred at Redding, California, on August 11, 1943.

Warden Love entered the service of the Division of Fish and Game as a game warden in August, 1929. His service with the Division has been principally in Shasta County where he was greatly respected by a host of friends and acquaintances.

Warden Love was forced to take sick leave in November, 1942, and was apparently suffering from a rather minor infection. His condition failed to improve after several months and he continued to grow steadily worse until the time of his death, in spite of the excellent care which he received.

Charley was a quiet, efficient officer in the prosecution of wilful violations of the law, and at the same time carried on a successful educational program among the younger generation in observance of conservation. He is survived by his wife and a son and daughter, to whom we extend our sympathy.—*L. F. Chappell, Chief, Bureau of Patrol, California Division of Fish and Game.*

ARTHUR BOEKE

It is with deep regret that we announce the death of Arthur Boeke, who was killed in an airplane crash in the Alaskan theater of activities while serving as a Second Class Radio Man in the United States Navy.

Mr. Boeke was born in South Dakota in 1910. He became a member of the Division of Fish and Game, Bureau of Licenses, on June 14, 1940. He was inducted in the Army March 5, 1941, and was sent to Fort Monmouth, New Jersey, for radio instruction. On August 1, 1941, he returned to the employment of this Division, having been discharged from the Army on account of four years previous service with the United States Marines in China.

On May 12, 1942, he joined the United States Navy and was assigned to the Oklahoma Agricultural and Mechanical College, Stillwater, to continue his studies in radio work. Upon graduation he went to Treasure Island, San Francisco, and later to the naval air patrol at Mills Field. In March of 1943 he was assigned to C G Photo Expedition Flight Air Wing 4, Patsu 3, Alaska. He was married just before his departure for Alaska.

In the few years that Mr. Boeke was in the employ of this Division he endeared himself to his fellow workers for his pleasant and congenial personality and proved himself to be a most capable and efficient worker. His devotion to duty is well exemplified by his service in his country's defense.—*H. R. Dunbar, Chief, Bureau of Licenses, California Division of Fish and Game.*

REPORTS

FISH CASES

April, May, June, 1943

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalones: Overlimit, undersize, no license, removal from shells below high tide	162	$4,280 00	
Abalones: Possession in District 2 and taken in District 2½, no affidavit	11	275 00	
Bass, Black: No license, closed season, overlimit, undersize	31	850 00	
Bass, Striped: After sunset, undersize, more than one pole, no license, overlimit, for sale	31	600 00	
Catfish: Selling undersize, closed season	3	75 00	
Clams: Closed season, taking in preserve 18a, overlimit, undersize, no license	27	630 00	
Crabs: Undersize	1	25 00	
Crappie: Closed season	15	400 00	
Frogs: Overlimit	2	50 00	
Game fish: No license, closed season	30	555 00	
Lobsters: Closed season	1	200 00	
Lobsters, spiny: Undersize	1	50 00	
Perch: No license, closed season	3	60 00	
Salmon: Other than angling, closed season, undersize	3	100 00	
Sturgeon: Possession	2	50 00	
Sunfish: Closed season, overlimit	27	685 00	
Trout: More than one pole, closed season, no license, overlimit	41	1,225 00	
Yellowtail: Selling without commercial license	1	25 00	
Angling: Closed season, no license, more than one pole	54	1,050 00	
Failure to show license on demand	1	25 00	
Failure to keep record of fresh fish purchased and from whom	1	100 00	
Failure to return bass to water taken in shad net, possession sturgeon	4	170 00	
False statement to secure fishing license	2	110 00	
Fishing within 150 ft. of lower side of dam	1	25 00	
Fishing in fish ladder	1	25 00	
Fishing in closed waters	12	275 00	
Lending license to another	1	50 00	
Operating drift gill net in Mexican drift District 12C	1	100 00	
Operating gill net in District 2	3	100 00	
Pollution	5	525 00	5
Possession fish and fishing equipment in fish refuge	1	25 00	
Possession spear in prohibited area	5	125 00	
Taking fish with net or trap	1	100 00	
Taking fish other than with hook and line	2	50 00	
Taking marine life within marine refuge	1	25 00	
Using another's license	3	85 00	
Using trawl net in 12½ fathoms of water in District 17	4	400 00	
Wilful waste of food fish	1	25 00	
Totals	496	$13,525 00	5

GAME CASES

April, May, June, 1943

Offense	Number arrests	Fines imposed	Jail sentences (days)
Beaver: No commercial license	1	$75 00	
Deer: Closed season, killing doe	7	1,250 00	
Deer Meat: Closed season	26	2,090 00	
Doves: Closed season	2	75 00	
Ducks: Closed season, shore bird, overlimit, possession wild baby ducks	4	325 00	
Ducks: Taking young from nest	1	50 00	
Geese: Closed season	1	35 00	
Non-game birds	1	50 00	
Pheasants: Closed season	27	1,740 00	
Quail: Closed season	2	75 00	
Rabbits, Cottontail: Closed season	4	125 00	
Sage hens: Possession	2	200 00	
Disturbing traps of licensed trappers	1	10 00	
Hunting: No license, failure to show license on demand	5	80 00	
Night hunting and using artificial light	2	200 00	
Possession spotlight and rifle in deer inhabited area	2	70 00	
Possession firearms in game refuge	1	50 00	
Shooting before and after legal time	6	175 00	
Shooting from automobile, killing mallard duck, no license	1	175 00	
Spotlighting	6	150 00	
Trapping bear in refuge, discharging firearms in refuge	2	100 00	
Totals	104	$7,100 00	

SEIZURES OF FISH AND GAME

April, May, June, 1943

Fish:	
Abalones	75
Abalones, black	103
Abalones, green	8
Abalones, red	529
Bass, black	88
Bass, striped	25
Catfish	12
Catfish, pounds	16
Crappie	66
Clams, cockles	102
Clams, horseneck	15
Clams, pismo	164
Lobsters, spiny	8
Sunfish	377
Sunperch	25
Trout	247
Trout, loch leven	7
Trout, rainbow	175
Trout, steelhead	229
Game:	
Deer	3
Deer meat, pounds	158
Deer meat, jars	20
Doe	2
Doves	5
Ducks, mallard	7
Geese, Canada	1
Pheasants	9
Pheasants, male	19
Pheasants, hen	6
Quail, valley	2
Rabbits, cottontail	12
Sagehens	1
Shorebirds	1

STATEMENT OF REVENUE

For the Period July 1, 1942, to June 30, 1943, of the 94th Fiscal Year

Revenue for Fish and Game Preservation Fund:		
License Revenue:		
1943 Series—		
Angling		$299,189 50
Hunting		155 00
Trapping		3 00
Fish packers and shell fish dealers		20 00
Deer tags		9 00
Fish tags		2,267 36
Game tags		58 47
Market fishermen		68,140 00
Fish importers		20 00
Fish party boat permits		226 00
Fish breeders		250 00
Game breeders		882 50
Game management—Licenses		140 00
Game management—Tags		1 14
Kelp license		10 00
Total 1943 series		$371,431 97
1942 series—		
Angling		$571,541 00
Hunting		508,785 00
Commercial hunting club		725 00
Commercial hunting club operator		280 00
Trapping		1,177 00
Fish packers and shell fish dealers		920 00
Deer tags		116,042 00
Fish tags		1,722 00
Game tags		158 67
Market fishermen		52,850 00
Fish importers		5 00
Fish party boat permits		86 00
Fish breeder		35 00
Game breeder		102 50
Kelp license		20 00
Total 1942 series		$1,254,449 17
1941 series—		
Angling		$426 00
Hunting		13,406 50
Deer tags		39 00
Total 1941 series		$13,871 50
Total licenses 94th fiscal year		$1,639,752 64
Other revenue:		
Court fines	$31,762 10	
Deer meat permits	6,767 00	
Lease of kelp beds	1,334 50	
Publication sales	549 38	
Fish packers tax	299,823 19	
Kelp tax	1,671 17	
Salmon packers tax	35,598 25	
Miscellaneous	28,944 89	
Total other revenue		406,450 48
Grand total revenue all years, Fish and Game Preservation Fund		$2,046,203 12

STATEMENT OF EXPENDITURES

For the Period July 1, 1942, to June 30, 1943, of the 94th Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Administration:					
Demolition of exposition exhibits			$10 21		$10 21
Education and public information	$2,900 00	$49 99	310 77		3,260 76
Executive	7,804 92	429 58	3,342 97		11,577 47
Exhibits			71 47		71 47
Fish and game magazine		1,984 64			1,984 64
Library	2,351 62	428 25	58 30	$323 32	3,161 49
Office	12,706 13	2,206 43	75,875 51	3 61	90,791 68
Total Administration	$25,762 67	$5,098 89	$79,669 23	$326 93	$110,857 72
Patrol and Law Enforcement:					
Cannery inspection	$19,211 58	$45 94	$562 92		$19,820 44
Executive	15,547 41	315 61	1,605 60		17,468 62
Land patrol	282,056 50	16,589 16	61,411 18	$9,833 72	369,890 56
Marine patrol	62,668 25	5,201 98	25,957 80	3,623 17	97,451 20
Office	10,003 15	77 90	927 15	4 43	11,012 63
Pollution patrol	10,990 31	456 33	1,790 72	41 55	13,278 91
Total Patrol and Law Enforcement	$400,477 20	$22,686 92	$92,255 37	$13,502 87	$528,922 36
Marine Fisheries:					
Central Valleys investigation	$4,070 44	$421 44	$2,940 81	$9 51	$7,442 20
Executive	8,410 00	90 07	894 44	7 60	9,402 11
Field supervision	125 00				125 00
Fish cannery auditing			4,131 08		4,131 08
Office	15,297 81	108 95	250 64	77 38	15,734 78
Research and statistics	58,762 12	4,546 90	9,611 03	3,995 84	76,915 89
Shark liver analysis		93 55	6,500 00		6,593 55
Total Marine Fisheries	$86,665 37	$5,260 91	$24,328 00	$4,090 33	$120,344 61
Fish Conservation:					
Biological survey	$11,326 60	$472 38	$880 29	$82 84	$12,762 11
Executive	12,445 00	167 64	661 04		13,273 68
Field supply	5,747 78	136 64	713 87		6,598 29
Fish food unallocated		9,433 45	6,838 25		16,271 70
Fish planting	2,724 59	424 68	1,919 66		5,068 93
Fish rescue	9,809 62	359 82	2,357 19	165 23	12,691 86
Office	7,295 87	38 05	789 60		8,123 52
Operating expense unallocated		260 92			260 92
Pollution inspection	4,045 00	152 45	740 69		4,938 14
Statistical	3,052 12	154 50	1,356 00		4,562 62
Structural maintenance	2,295 02	153 64	623 91		3,072 57
Alpine Hatchery	829 47	304 39	149 98	54 59	1,338 43
Arrowhead Lake Egg Collecting Station		90 51	6 65		97 16
Basin Creek Hatchery	6,329 40	1,326 75	600 80	12 77	8,269 72
Bear Lake Egg Collecting Station			40 00		40 00
Benbow Dam Experiment Station	1,298 39	50 25	74 49	2 00	1,425 13
Black Rock Springs Ponds			55 50		55 50
Bogus Creek Egg Collecting Station			85 00		85 00
Brookdale Hatchery	7,743 12	1,485 26	616 19	22 61	9,867 18
Burney Creek Hatchery	5,248 81	1,094 73	380 09		6,723 63
Central Valley Hatchery	5,555 43	669 69	1,593 34	2 81	7,821 27
Claremont		186 76			186 76
Copco Egg Collecting Station			85 00		85 00
Coy Flat Station	1,195 50	219 00	211 48		1,625 98
Experimental Hatchery	486 48				486 48
Fall Creek Hatchery	7,005 66	605 67	220 11	46 80	7,878 24
Feather River Hatchery	5,396 83	322 25	397 77	11 21	6,128 06
Fillmore Hatchery	19,491 94	6,717 70	4,582 40	52 92	30,844 96
Fort Seward Hatchery	1,640 00	270 23	339 63		2,249 86
Fishing Creek			150 00		150 00
Hot Creek Hatchery	14,942 09	13,588 92	2,850 60	62 73	31,444 34
Huntington Lake Hatchery	690 17	33 46	149 35		872 98
Kaweah Hatchery	4,323 53	584 75	839 34	11 01	5,758 63
Kern Hatchery	3,152 65	778 46	834 48	72 72	4,838 31
Kings River Hatchery	6,337 02	2,158 53	641 21		9,136 76
King Salmon Experiment Station			30		30
Kirman Lake Egg Collection Station	481 46		10 05		491 51
Klamathon Egg Collecting Station		28 67	24 25		52 92
Lake Almanor Hatchery	7,768 37	822 92	1,010 76		9,602 05

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1942, to June 30, 1943, of the 94th Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Fish Conservation—Continued:					
Little Walker Lake Egg Collecting Station	$459 18		$3 75		$462 93
Madera Hatchery	2,685 53	$372 81	597 79	$30 84	3,686 97
Mad River Egg Collection Station	861 00				861 00
Mt. Shasta Hatchery	43,955 73	9,011 26	2,697 11	35 87	55,699 97
Mt. Tallac Hatchery	3,050 06	805 33	303 33	24 18	4,182 90
Mt. Whitney Hatchery	18,319 43	12,262 25	4,339 23	30 40	34,951 31
Prairie Creek Hatchery	6,134 00	1,713 09	397 52		8,244 61
Rearing Reservoir	1,270 00	329 42	611 38		2,210 80
Rush Creek Egg Collecting Station	253 33		10 00		263 33
San Lorenzo Egg Collecting Station		8 66	109 65		118 31
Sequoia Experiment Station	2,751 17	992 68	1,172 36	138 57	5,054 78
Shasta River Egg Collecting Station	4,031 00	5 07	112 16		4,148 23
Snow Mountain Egg Collecting Station	1,844 11	149 81	194 02		2,187 94
Tahoe Hatchery	7,661 98	1,824 10	1,229 29	240 26	10,955 63
Waddell Creek Station	206 45	25 26	18 92		250 63
Yosemite Hatchery	5,256 13	250 15	280 49		5,786 77
Yuba River Hatchery	3,564 19	260 72	78 14	1 29	3,904 34
Total Fish Conservation	$260,961 21	$71,103 68	$44,984 41	$1,101 65	$378,150 95
Engineering:					
Engineering	$9,560 85	$785 37	$2,935 69		$13,281 91
Executive	5,005 00	130 47	765 19		5,900 66
Inspecting fish screens	1,438 36	365 62	70 34		1,873 72
Office	1,672 91	33 23	27 02		1,733 16
Total Engineering	$17,677 12	$1,314 69	$3,798 24		$22,790 05
Game Conservation:					
Duck rescue	$386 75	$11 17	$610 51		$1,008 43
Elk Refuge	2,390 00	57 71	426 40		2,874 11
Executive	10,985 00	509 46	1,873 63	$57 24	13,425 33
Game management	13,832 70	1,871 91	3,254 23	138 76	19,097 60
Grey Lodge	4,603 71	483 82	212 82	41 96	5,342 31
Honey Lake Refuge		24 00	71 96	550 00	645 96
Imperial Refuge	2,604 48	62 50	211 34		2,878 32
Los Banos Refuge	4,208 88	555 67	437 57	102 43	5,304 55
Office	4,365 81	50 02	184 91	1 16	4,601 90
Predatory Animal—lion hunting	6,495 80	512 20	4,997 44	223 70	12,229 14
Predatory Animal—trapping	47,912 21	2,840 56	10,010 49	58 09	60,821 35
Research	10,869 50	639 98	1,395 39	61 51	12,966 38
Statistics	299 84	175 38	783 67		1,258 89
Suisun Refuge	4,516 50	507 09	352 11		5,375 70
Winter feeding and salting of game		97 03			97 03
Total Game Conservation	$113,471 18	$8,398 50	$24,822 47	$1,234 85	$147,927 00
Game Farms:					
Castaic farm	$1,950 26	$1,335 78	$164 29		$3,450 33
Executive	4,365 00	190 25	185 92		4,741 17
Chino farm		7 97			7 97
Fresno farm	2,616 27	588 83	370 65		3,575 75
Game Bird Distribution—Los Serranos	1,480 00	64 55	1 89		1,546 44
Game Bird Distribution—Yountville		139 75	100 71		240 46
Game management	1,892 50	54 02	179 13		2,125 65
Los Serranos game farm	8,915 16	3,410 69	1,392 90		13,718 75
Office	1,460 00		7 99		1,467 99
Redding farm	1,960 00	276 77	300 77	$85 59	2,623 13
Sacramento State Farm	1,970 00	291 27	99 24		2,360 51
Valley Center farm	110 00		20 30		130 30
Willows farm	2,095 00	839 61	193 03		3,127 64
Yountville boarding house	450 14	239 56	17 44		707 14
Yountville game farm	22,351 98	6,061 61	2,464 58	779 46	31,657 63
Total Game Farms	$51,616 31	$13,500 66	$5,498 84	$865 05	$71,480 86
Licenses:					
Executive	$4,365 00	$49 21	$436 13		$4,850 34
License distribution	18,108 02	4,542 62	72,994 60	$205 38	95,850 62
Office	2,229 82	46 98	1,345 51	7 51	3,629 82
Total Licenses	$24,702 84	$4,638 81	$74,776 24	$212 89	$104,330 78
Grand totals					$1,484,804 33

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